THE ENGINE RUNNER'S CATECHISM

A work containing correct answers to direct questions on how to erect, adjust, and run the principal steam engines used in the United States

Engineers and others preparing to be examined for certificates of competency or where direct information is desired will find the instructions given complete and up-to-date, being a sequel to the author's "Steam Engine Catechism"

BY
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SEVENTH EDITION

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PREFACE.

The remarkable and gratifying appreciation and success attending the publication of the author's original "Steam Engine Catechism" (now in its 12th edition) and of its companion volumes, the "Pump Catechism" and "Boiler Catechism," has led to the preparation of this book, which treats more of special builds of engines, as erected, adjusted, and run, than of the properties of steam, or the general principles of engine design and construction. It has seemed desirable to give descriptions of the general characteristics of various well-known makes of engines; to follow these with details of shipping, making foundations, erecting, and starting, and then to give detailed instructions as to the adjustment of special makes, each of which has its own peculiarities of construction, often puzzling even to engineers of long and

varied experience. This last feature, in particular, should prove specially valuable to young engineers, or to those in isolated plants, where opportunities for communicating with other engineers, or with the builders of an engine that may be unfamiliar, are few. The author has tried to make his instructions plain, complete, accurate, and up to date. Should it fail in any item, he would take it as a favor to be told of errors, or asked concerning omissions.

PREFACE TO SEVENTH EDITION.

This work has been carefully revised and much new matter added with cuts to illustrate the engines described, believing it will enhance the value of the work and prove of interest to the engineer and steam user.

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CONTENTS.

SOME MODERN ENGINES.*

THE ARMINGTON & SIMS ENGINE.

Q. What features distinguish the Armington & Sims engine?

A. The Armington & Sims engine has overhung cylinder, governor of the same type as the Buckeye and Straight Line, a hollow double-ported piston valve, but taking steam at the middle and exhausting as the ends of the chest. One eccentric is set inside the other, and the governor causes their throws to coincide, producing maximum throw, or to separate, lessening the throw.

Q. What is the range of cut-off in the Armington & Sims engine?

A. From zero to three-quarters.

Q. How does change of cut-off affect the

* Full instructions how to set up, adjust and run these various engines are given in the chapter devoted to that subject, page 153, *et seq.*

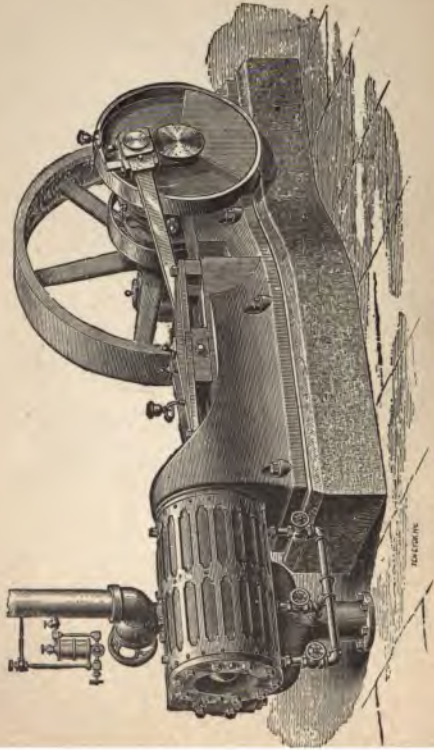


FIG. 1. ARMINGTON & SIMS ENGINE.

lead and cushion in the Armington & Sim's engine?

A. The earlier the cut-off, the greater the compression; lead remains unchanged.

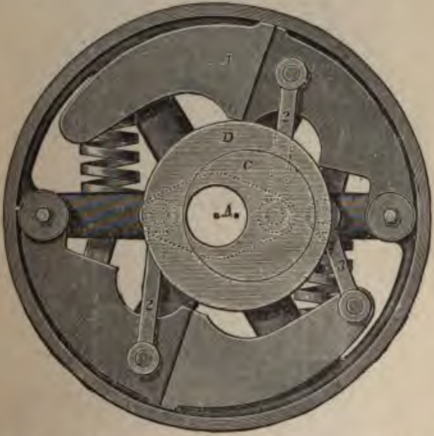


FIG. 2. ARMINGTON & SIMS GOVERNOR. — EARLY CUT-OFF.

THE ATLAS SLIDE-VALVE ENGINE.

Q. What is the principal characteristic of the Atlas slide-valve engine?

A. A shaft-governor, made of ten pieces including three pairs of duplicates. In the

FIG. 3. ARMINGTON & SIMS GOVERNOR.—LATE CUT-OFF.

cut, *A* is the shaft bore, *B* the "tripod," a sleeve fitting the shaft and having three arms with studs for the attachment of other parts. The stud in its longest arm comes 180° from the crank-pin. On this stud is hung the eccentric *C*, which has a hole large

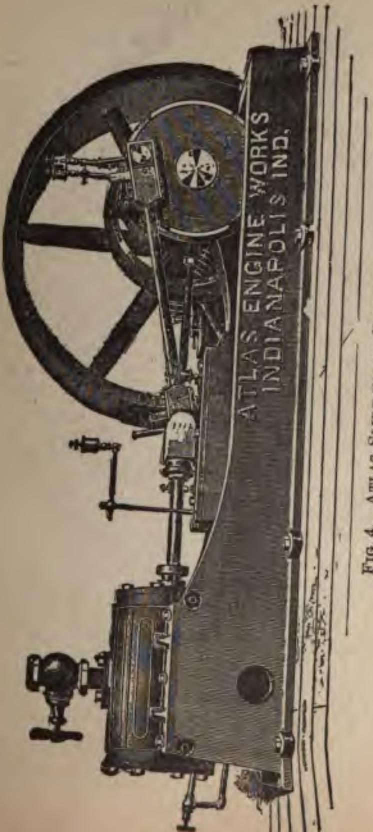


FIG. 4. ATLAS SLIDE-VALVE ENGINE.

enough to let it swing across the shaft to vary its throw. It has a gibbed rebate (or rabbet) to fit over a projecting lip on the tripod. A pulley-like piece D fits over the tripod sleeve and is held by a collar. It fits loosely, so that the sleeve may turn within it without turning it, hence it is called the "dead-wheel." Two weights, E, F, are pivoted thereto; set-screws limiting their throw.

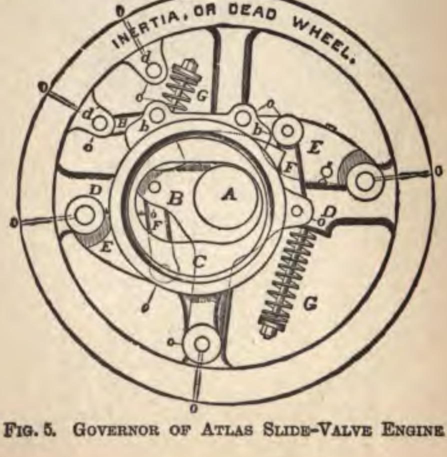


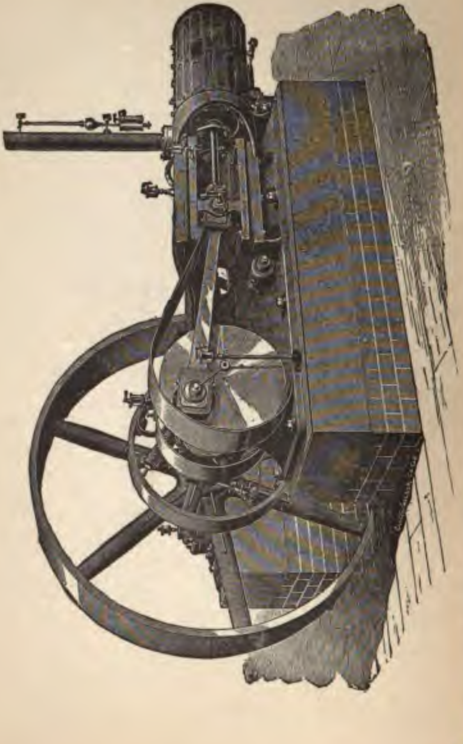
FIG. 5. GOVERNOR OF ATLAS SLIDE-VALVE ENGINE

Each weight has a stud whereby it is connected to the shorter arms of the tripod by a "weight link," *F*. The "eccentric link," *H*, connects the eccentric with the rim of the dead wheel. There are two pairs of lugs, *b d* and *b′ d′*. Taper pins are used in them to take up the wear. The link connects one pair when the engine runs *over*, and the other when running *under*. The remaining pieces are the two "springs," *G G*, with their rods, nuts and washers. The rods are pivoted to the weights, and the springs rest upon lugs on the arms of the dead-wheel. The springs are alike, and act as one.

THE BUCKEYE ENGINE.

Q. What are the salient features of the "Buckeye" engine?

A. In the "Buckeye" engine, designed by J. W. Thompson, the main valve is box-shaped, and the steam enters it and passes through ports in this valve into the cylinder ports. The cut-off valve consists of two sliding plates, connected by rods, and slid-



ing on seats in the inner side of the main valve. The cut-off valve stem passes through the main valve stem. The valve is balanced by relief chambers, when needed. The governor is on the main shaft, and shifts the cut-off eccentric.

Q. What is the cut-off range of the Buckeye engine?

A. From zero to five-eighths.

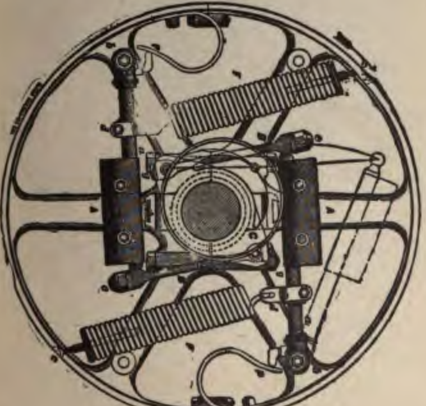


FIG. 7. BUCKEYE GOVERNOR.

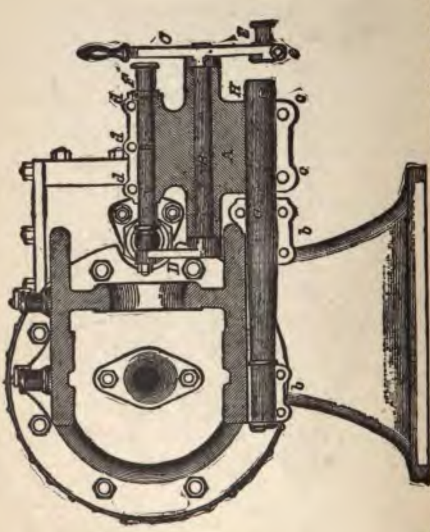


FIG. 8. CROSS SECTION, BUCKEYE ENGINE, SHOWING ROCK ARM.

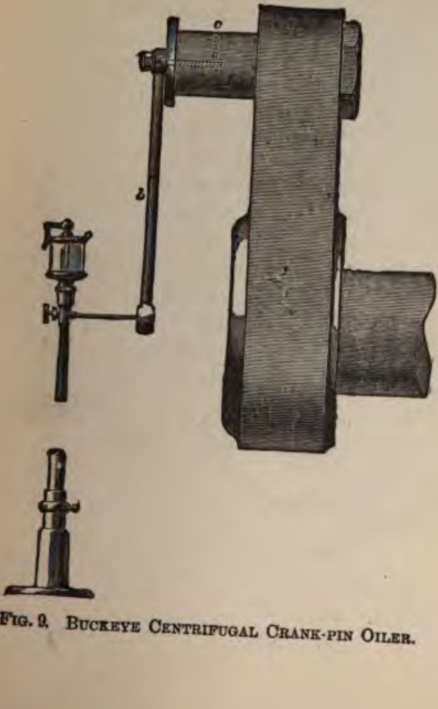


FIG. 9. BUCKEYE CENTRIFUGAL CRANK-PIN OILER.

THE CUMMER ENGINE.

Q. What are the main distinguishing features of the Cummer engine?

A. Meyer cut-off valves, riding on the back of the main or admission valve; exhaust valves independent of admission and cut-off, all valves gridirons; governor on a shaft separate from the main shaft, but parallel thereto, and driven by gearing therefrom; two eccentrics on the governor shaft; one of them loose on the shaft, and controlled, as to position, by links from the weights of the governor.

Q. What is the piston speed in feet per minute for the Cummer engine?

A. Four hundred times the cube root of the stroke in feet. Thus, for three feet stroke, $400 \times 1.442 = 576.8$ feet per minute (say 575 to 600).

THE ECLIPSE CORLISS ENGINE.

Q. Describe the Eclipse (Frick) Corliss engine.

A. The wrist-plate motion, Fig. 10, is of the most familiar Corliss form known.

The dash pots, Figs. 11 and 12, act on the vacuum principle. The bed-plate or frame is of the girder type. The crosshead, Figs. 13, 14, and 15, runs in V-guides; the piston, Figs. 16 and 17, is spring-packed.

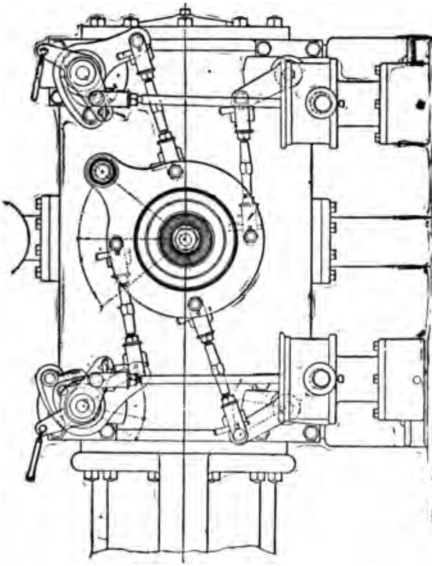


FIG. 10. WRIST-PLATE MOTION, ECLIPSE CORLISS ENGINE.

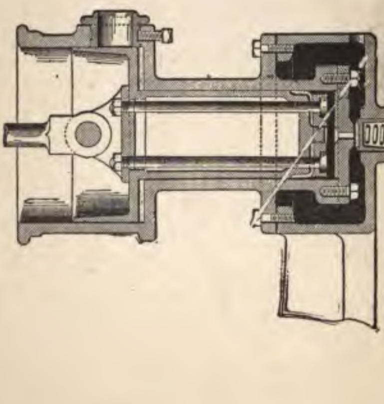


Fig. 11. Vertical Section Eclipse Dash Pot.

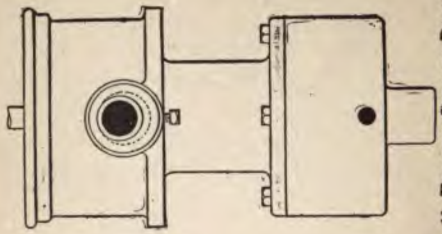
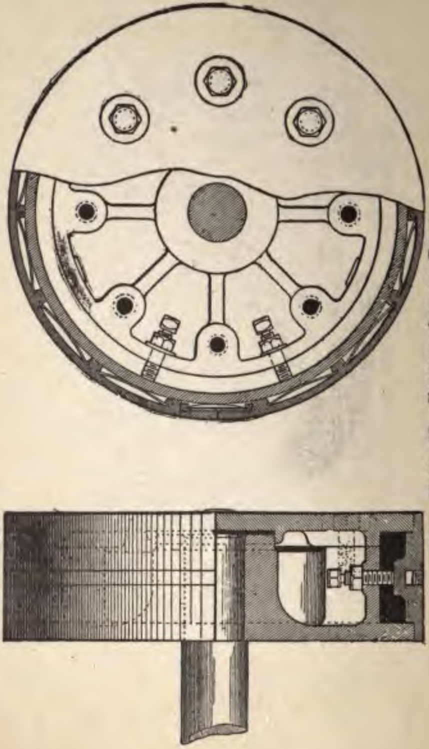
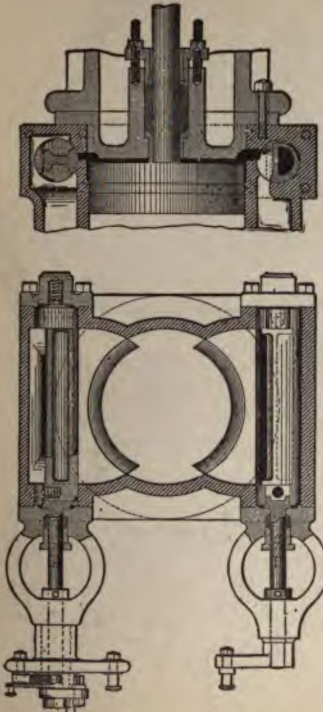


Fig. 12 Eclipse Corliss Dash Pot.

FIGS. 13, 14 AND 15. ECLIPSE CORLISS CROSSHEAD.



FIGS. 16 AND 17. ECLIPSE-CORLISS PISTON.



FIGS. 18 AND 19. ECLIPSE CORLISS STEAM AND EXHAUST VALVES.

THE FITCHBURG ENGINE.

Q. Describe the Fitchburg horizontal automatic cut-off engine.

A. The valve-gear is positive, with independent steam and exhaust valves. The upper valves, worked by a wrist-plate, control admission and cut-off; the lower control the exhaust and are adjustable independently of the others, but not automatically. The valves are pistons (see Figs. 22 and 23) with double ports, and are expansible to take up wear. The exhaust valves are on a line with the cylinder bottom. The governor (Fig. 21) has weights *O*, acting on fulcrums *D*, to balance the weight of the eccentric and strap. The connecting rod *G* is attached to the suspension arm *C* at *E*, acting directly on the eccentric, while the opposite rod *G'* is attached to the opposite arm *C* at *F*, acting over the pin *D* as a fulcrum so that the outward motion of both the centrifugal weights *H* acts with equal power to move the eccentric across the shaft. By transferring the ends of the rods

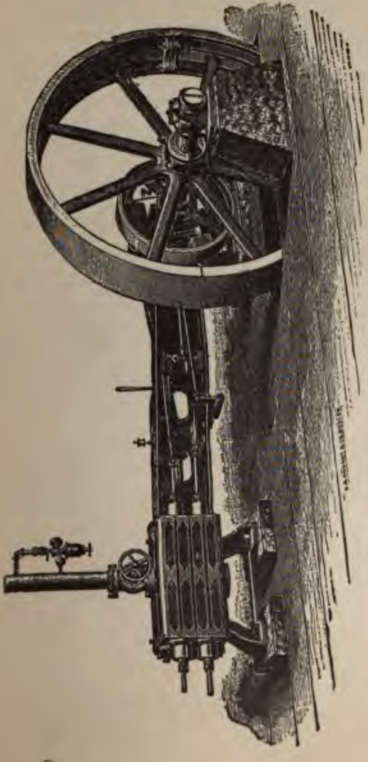


FIG. 20. FITCHBURG GIRDER FRAME ENGINE.

FIG. 21. FITCHBURG GOVERNOR.

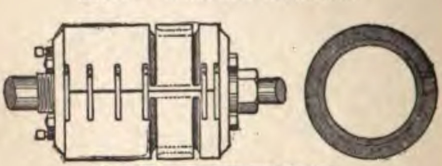


FIG. 22. FITCHBURG VALVE.

GG' from *E* to *F* and from *F* to *E* respectively the outward motion of the weights *H* throws the eccentric the other way and runs

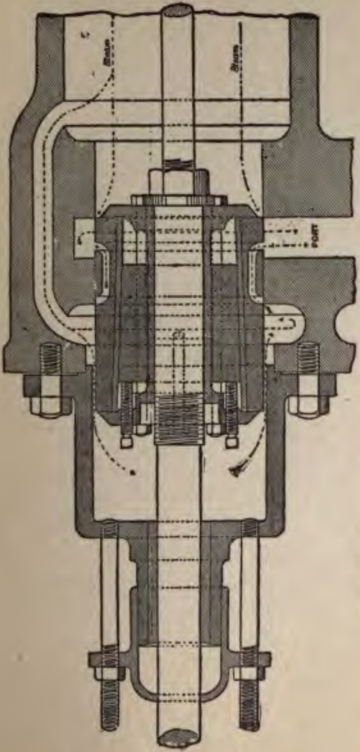


FIG. 23. SECTION OF FITCHBURG VALVE AND PASSAGES.

the engine the other way; a new eccentric, also in halves and with opposite offset being substituted.

When the engine is below speed the eccentric is kept in its longest throw by the spring tension, and steam follows three-fourths

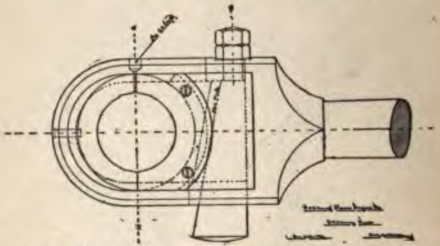


FIG. 24. FITCHBURG CONNECTING ROD END.

stroke; but with proper speed the centrifugal action of the weights *H* overcarries the spring tension, and they move in the direction of the arrows, lengthening the springs and sliding the eccentric across the shaft from *S* towards *R*, lessening the eccentricity and giving earlier cut-off.

THE GREENE ENGINE.

Q. What is the essential feature of the Greene engine?

A. There are four flat valves; the steam valves are attached to the cut-off gear by stems *D*, *D'*, shown in the detailed view, Fig. 26, parallel to their seats, passing through stuffing boxes *E*, *E'*, and connected to rock shafts, and driven by a sliding bar *J*, actuated by an eccentric set to drive it parallel with the cylinder axis, and coincident with the piston. This bar bears a pair of tappets *G*, *G'*, adjusted vertically to engage drop toes *KK'* on rock shaft arms *BB'* on rock shafts *AA'* attached to the valve links inside the steam chest. The tappets were formerly held to their work by springs, and their position regulated by a Porter governor. They now have direct and rigid connection with the governor. The exhaust valves are gridiron slides travelling across the cylinder line, and driven by a horizontal rock shaft extending forward to the eccentric on the main shaft.

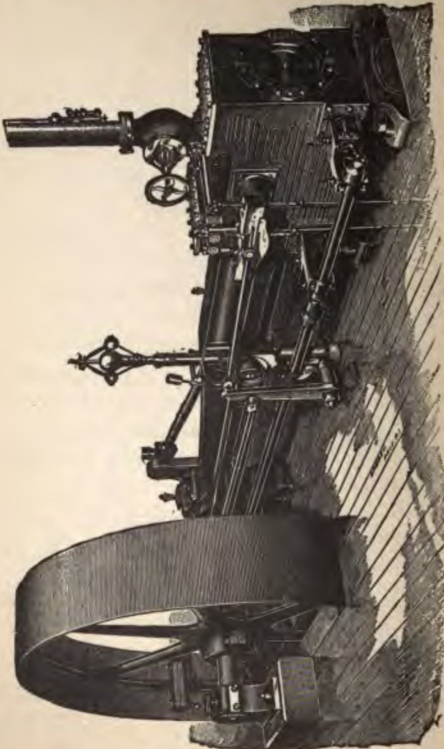


FIG. 25. GREENE ENGINE.

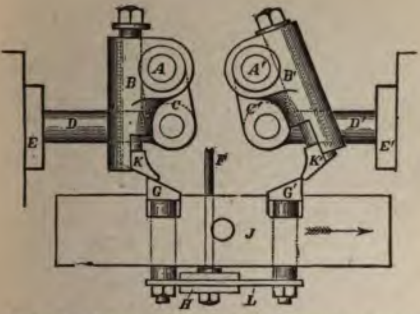


FIG. 26. CUT-OFF MECHANISM, GREENE ENGINE.

Q. What is the cut-off range in a Greene engine?

A. From zero to three-quarter stroke.

Q. What limits the latest point of cut-off in a Greene engine?

A. The lead, and the necessity of getting sure closure of the valve.

THE IDE ENGINE.

Q. What are the peculiar features of the Ide engine?

A. In those of early build, admission and exhaust valve under cylinder, to cause con-

FIG. 27. IDE CROSSHEAD PIN.

densed water to pass out with the exhaust. In the new type shown in the illustrations, relief diaphragms, Fig. 30, placed below cylinder, to burst and give relief in case water is worked into cylinder. Piston valve with spring ring packing and removable valve cylinders or bushings, to enable the valve to be maintained steam tight. Unhooking of eccentric rod to permit reversing the engine to warm cylinder before starting, and enable the engineer to locate lost motion or loose bearings, which cause thumping. An indicator, which shows the point of cut-off, and indicates the amount of power the engine is developing at all times. Solid ends to connecting rod, with wedge full

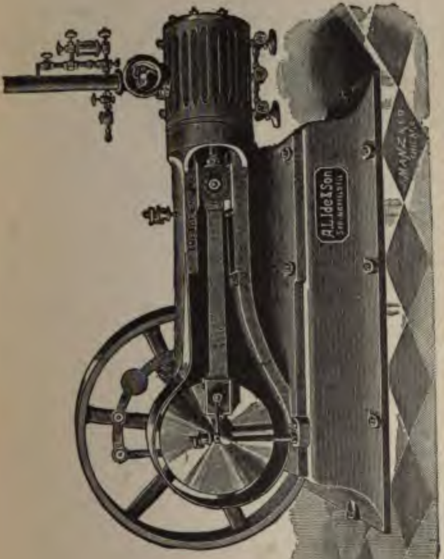


FIG. 28 IDE ENGINE, SIDE ELEVATION.

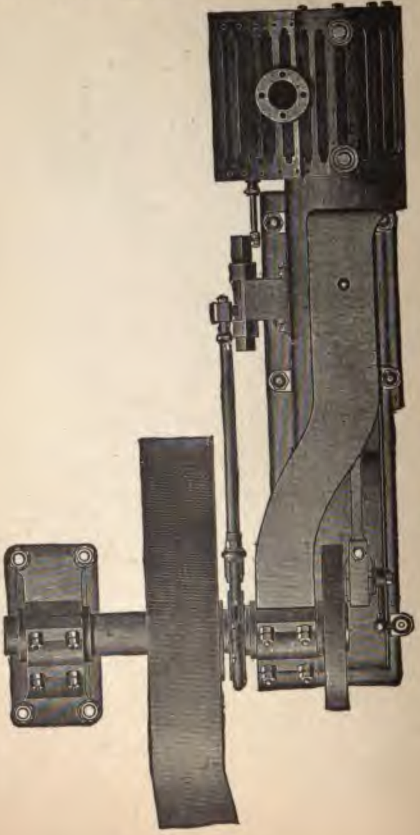


FIG. 20. IDE ENGINE, IN PLAN.

FIG. 30. IDE BURSTING PIECE.

width of rod. Crosshead of box form, Figs. 31, 114, and 115, playing in guides bored out the same size as the cylinder. Steam chest fitted with cylindrical bushings, Fig. 33. The valve (Fig. 33) is a hollow piston.

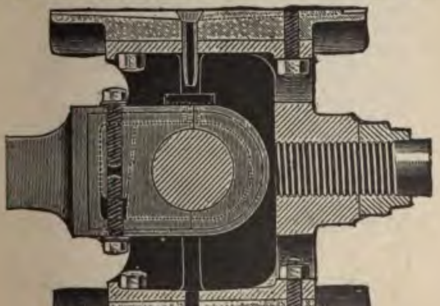


FIG. 31. IDE CROSSHEAD.

FIG. 32. IDE STEAM CHEST BUSHING.

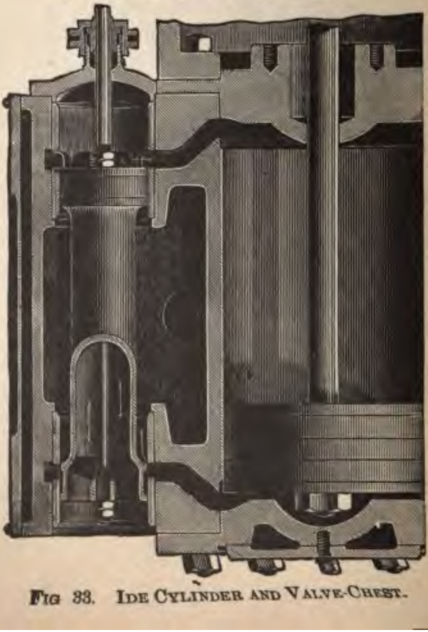


FIG 33. IDE CYLINDER AND VALVE-CHEST.

THE PORTER-ALLEN ENGINE.

Q. What are the essential characteristics of the Porter-Allen engine?

A. One eccentric, bearing a link which operates two steam valves and two exhaust valves, and the block of which is controlled by a Porter governor. The upper end of the link drives the exhaust direct. The link is pivoted at the middle on trunnions held by an arm rocking on a pin in the bed-plate. The steam valves are at the upper side of the cylinder, and the exhaust on the lower; but the valves are set on their edges at either side of the cylinder. Each valve admits steam at all four edges simultaneously.

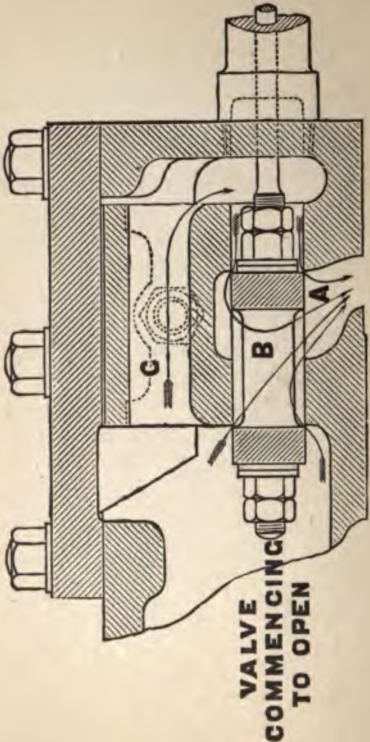


FIG. 34. PORTER-ALLEN VALVE.

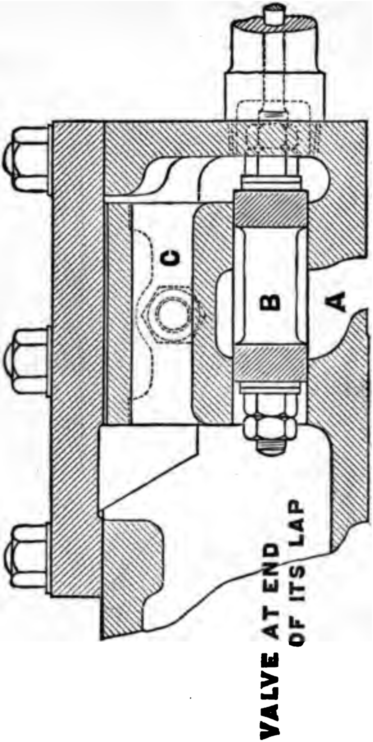


FIG. 35. PORTER-ALLEN VALVE.

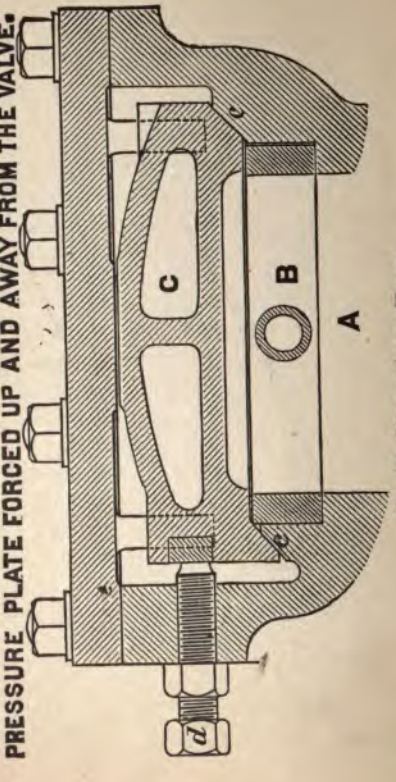


FIG. 36. PORTER-ALLEN VALVE.

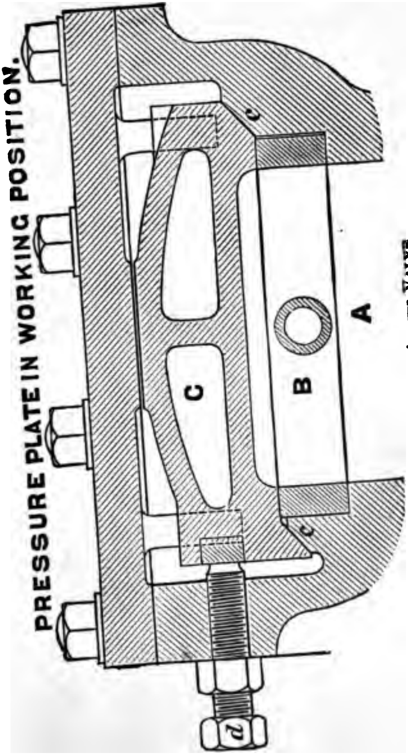


FIG. 37. PORTER-ALLEN VALVE.

THE PORTER-HAMILTON ENGINE.

Q. What are the principal characteristics of the Porter-Hamilton engine?

A. Overhung cylinder, a ribbed, hollow box-bed, of the Porter (usually called "Tangye") type, with the bottom of the guides a part of the main casting a main bearing split on its side, as shown in Fig. 43; valve seat at the side of the cylinder, and low down; a single slide valve balanced by a Margach plate, and with uniform motion, making two openings for admission; the second one by a passage behind the exhaust cavity, as shown in Fig. 38; although sometimes there is used a flat valve provided with a balance plate resting on ledges (see Fig. 40); wide hollow piston (see Fig. 38) forced on the rod, and the rod end riveted. The crosshead is purposely heavy. The overhang of the crank is very slight. The crank pin diameter is greater than its working length. There is a Kirkevaag drop hook (Fig. 41) which enables disconnection from the rocker pin without lifting the eccentric rod.

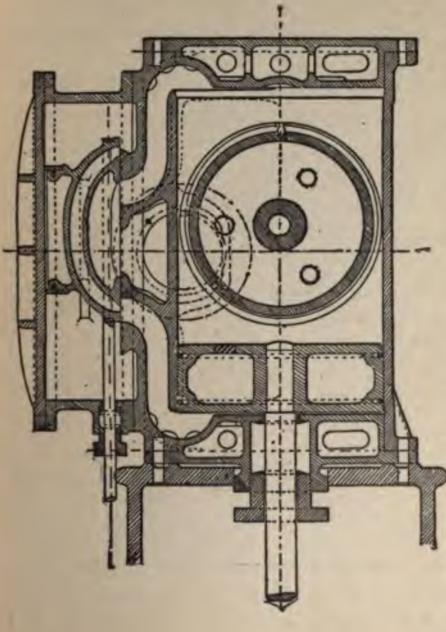


FIG. 38. CENTRAL VERTICAL LENGTHWISE SECTION, PORTER-HAMILTON ENGINE.

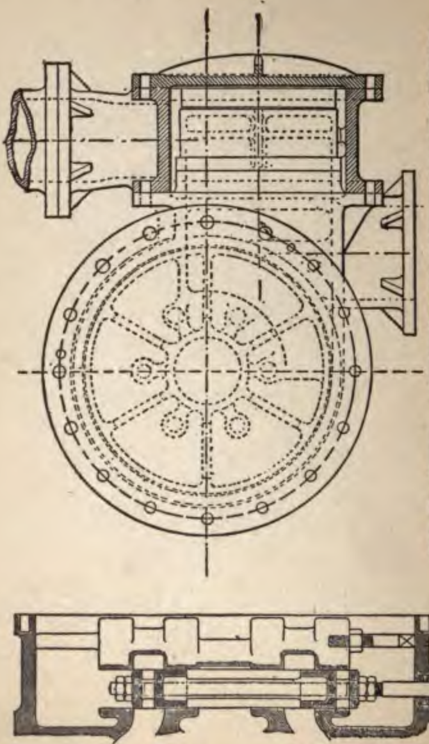


FIG. 39. VERTICAL CROSS SECTION, PORTER-HAMILTON ENGINE.

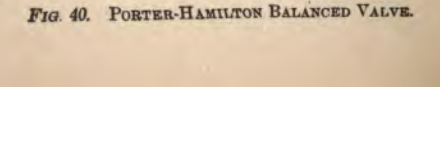


FIG. 40. PORTER-HAMILTON BALANCED VALVE.

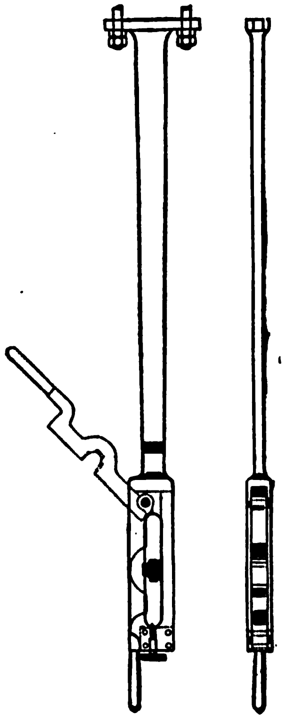


FIG. 41. KIRKEVAAG DROP HOOK.

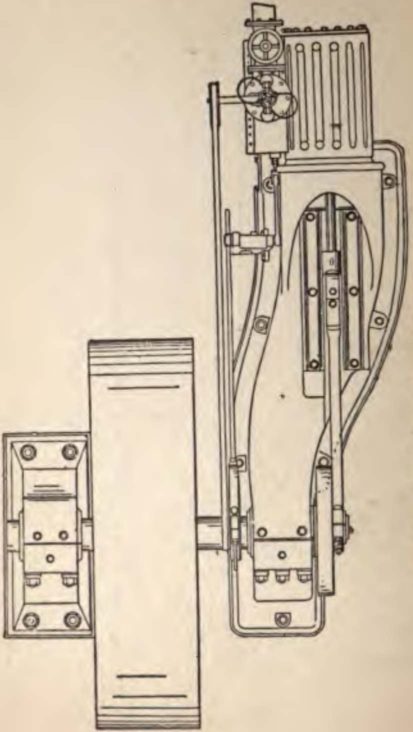


FIG. 42. PLAN VIEW, PORTER-HAMILTON ENGINE.

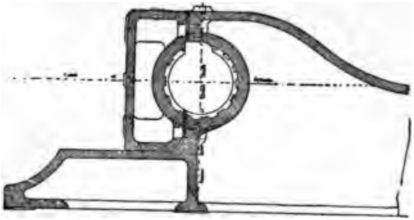


FIG. 43. PORTER-HAMILTON, MAIN BEARING.

THE PUTNAM ENGINE.

Q. What is the construction and operation of the valve gear of the Putnam high pressure, variable cut off engine?

A. The valves are operated by a side-shaft placed parallel with the axis of the cylinder, and extending beneath the valve-chests and operated by the main shaft through suitable gearings, as shown in Fig. 44. The steam chests are placed one at each end of the cylinder. On this shaft are placed four cams—one for each valve—shaped as shown in Fig. 46. The cams operate, by raising the free ends, cam-levers, which in turn actuate the valves. The two

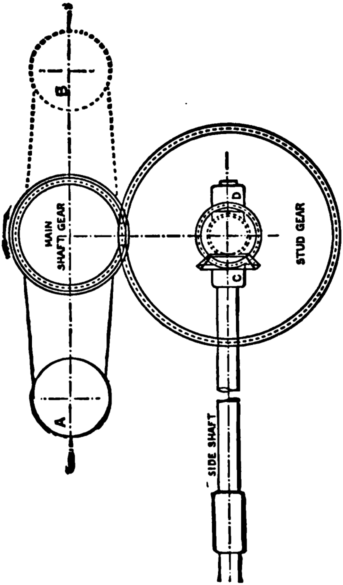


FIG. 44. SIDE SHAFT AND GEAR, PUTNAM ENGINE.

outer or exhaust cam-levers are journaled to arms projecting from the engine bed, so that their free ends have an up-and-down movement, but no horizontal movement toward or from the cam shaft. The move-

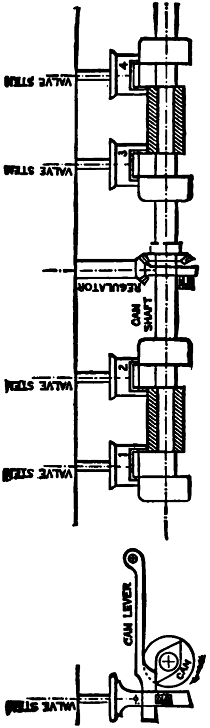


FIG. 45. CAM SHAFT, PUTNAM ENGINE.

ment of the exhaust valves, therefore, is never altered.

The outer ends of the levers operating the inlet valves are pivoted to the upper ends of arms rigidly secured to a shaft placed parallel with and outside of the cam-shaft, and having at its centre a third arm, *E*, Fig. 46, which extends to and unites with the governor rod. The governor, of the ball type, is driven by bevel gears from the cam shaft, and its lower end is slotted to inclose the cam shaft, and extend to the arm *E*. The raising and lowering of the governor rod will partly turn the shaft carrying the arm and thereby move the inlet-cam levers toward or from the valve stems in a horizontal direction. The free ends of these levers are shaped as shown in Fig. 46 the under side of the lever being cut away on a curve directly over the cam. When the cam lever is in the position shown in Fig. 46, it will not be lifted by the cam, which revolves in the direction of the hands of a watch. The governor balls are now at their highest possible point. In Fig. 47 the governor-balls are shown at their lowest

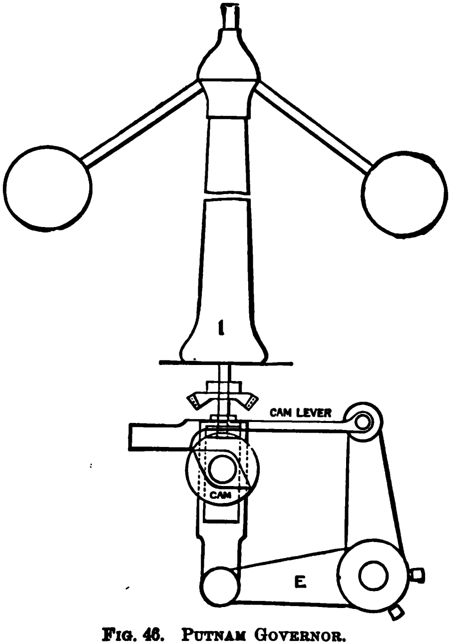


FIG. 46. PUTNAM GOVERNOR.

position, and the cam will now strike the shoulder of the lever and open the valves the longest possible time. The valves are

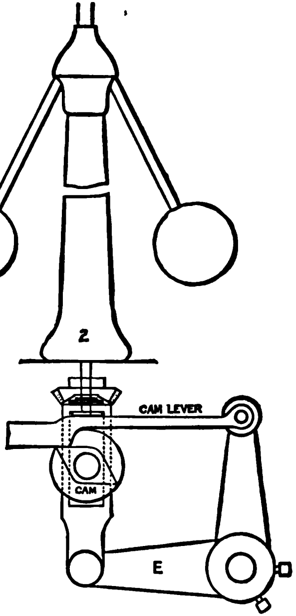


FIG. 47. PUTNAM GOVERNOR.

seated by their own weight and by the action of springs arranged as shown in Fig. 45, and also by the cams striking an inclined

projection on stands, thus making the return of the valve positive. Jarring of the valve at seating is prevented by the curved form of the shoulder on the cam lever, which rides upon the cam and brings the valve gently to its seat.

THE RUSSELL ENGINE.

Q. Describe the Russell engine?

A. Fig. 48 shows the design up to and including 11″ × 16″; Fig. 49, the 11″ × 18″ and upwards. The bed is "semi-girder" in type, on all sizes up to 11″ × 16″; on larger sizes it is of the so-called Tangye type, with locomotive girders, cylinder overhung; guides bored; crosshead pin in centre of length of the head; crosshead clamped to the piston rod; connecting rod with solid ends and wedge adjustments; crank of disc type. The governor (see Figs. 50 and 52) shifts the eccentric across the shaft, thus altering eccentric throw and valve travel. The lead is constant for all points of cut-off. There are two sets of governor weights pivoted near the case-rim. Their outward

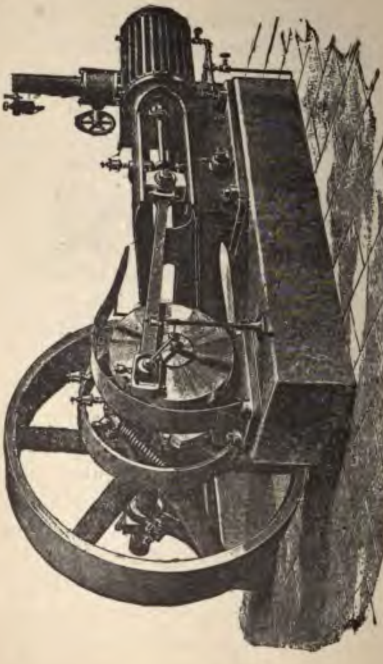


FIG. 48. RUSSELL ENGINE UP TO 11″ × 16″.

FIG. 49. RUSSELL ENGINE. 11″ 18″ × AND UPWARDS.

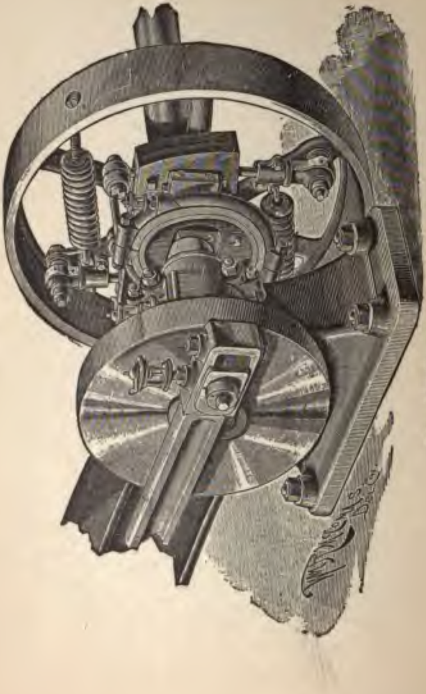


FIG. 50. RUSSELL GOVERNOR.

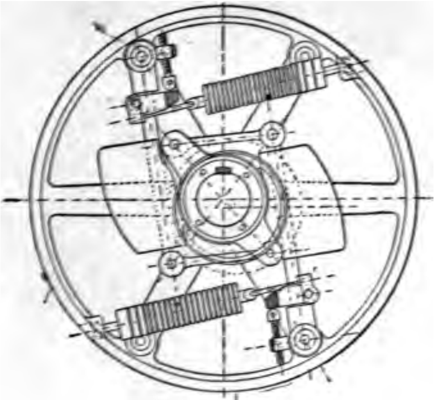


FIG. 52. RUSSELL GOVERNOR.

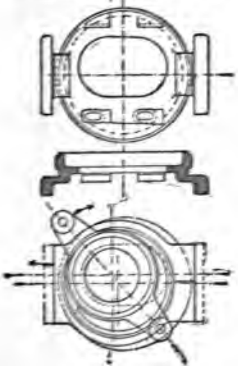


FIG. 51. RUSSELL GOVERNOR.

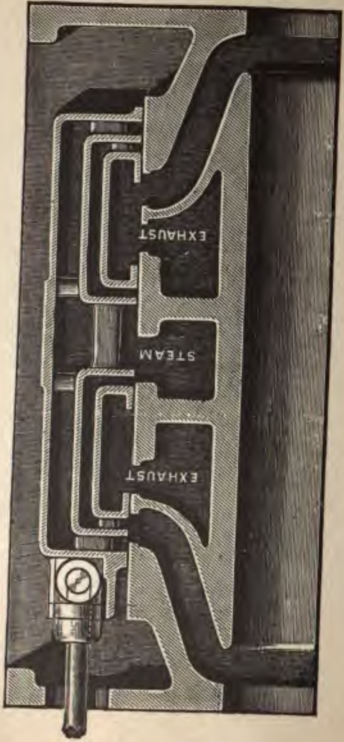


FIG. 53. RUSSELL SLIDE VALVE.

movement (which is resisted by regulatable springs) rotates the inner eccentric on the governor-case hub. The main (or valve-operating) eccentric is slotted to permit it to move across the shaft. The inner eccentric strap acts as a crosshead, converting the rotary motion of the inner eccentric into reciprocating motion of the main eccentric. The valve (see Fig. 53) is double ported and in one piece; takes steam internally, and has needle-hole ports through which enough pressure is carried to its back, to hold it to its seat. It can lift $\frac{1}{8}''$ on its seat.

THE STRAIGHT-LINE ENGINE.

Q. What are the principal features of the "Straight Line" engine?

A. The "Straight Line" engine of Prof. J. E. Sweet has two straight, diverging struts from the cylinder to the two main bearings; is carried on three points of support. There are two fly wheels, between

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* Instructions for setting up and adjusting will be found under head "Setting up and Adjusting."

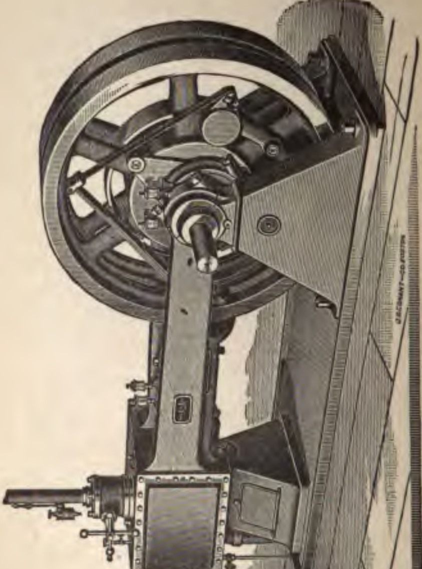

FIG. 54. STRAIGHT-LINE ENGINE, ELEVATION.

the main bearings, which serve as the crank. The valve chest is on the side, and in double valve engines on each side. There are no stuffing boxes, the rods passing through babbitted bushings. The crosshead is long and largely overruns the guides at each end of the stroke. The crosshead pin turns in two boxes in the crosshead and all are cut away at top and bottom. The valve is a rectangular plate, sliding between the seat and a pressure plate. There are recesses in the pressure plate opposite the steam and exhaust ports, and double ports through the valve, giving a double port opening to both steam and exhaust. The pressure plate can lift away from the valve in case of over-compression or of water in the cylinder. The eccentric has the Dodd motion, being carried on a lever pivoted at one side of the shaft, the governor rod being attached on the other side. Changing the cut-off gives a variable lead; positive at late cut-off and negative at early cut-off. The governor has a single ball, which is counterbalanced by the eccentric and its attachments, and a metal band is used in place of

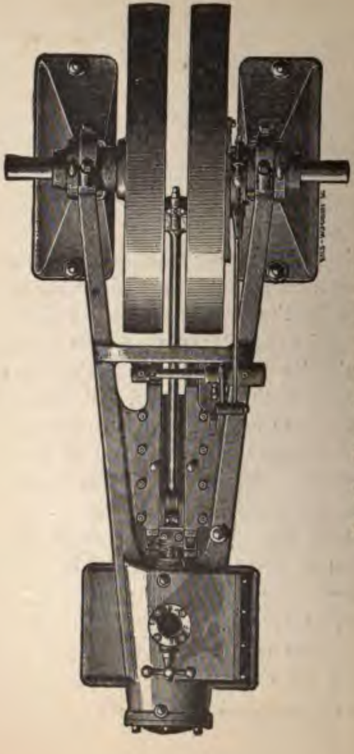

FIG. 55. PLAN, STRAIGHT-LINE ENGINE.

FIG. 56. HORIZONTAL SECTION THROUGH CYLINDER, STRAIGHT-LINE ENGINE.

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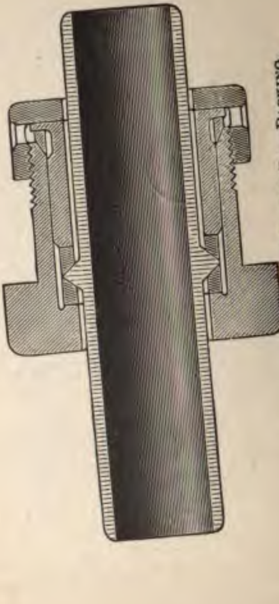

FIG. 60. "STRAIGHT-LINE" PISTON ROD PACKING.

THE TWISS ENGINE.

Q. Give a general description of the Twiss horizontal automatic cut-off engine.

A. The general design is of the Corliss or girder type. The cylinder frame and pillow block are cast separately and bolted together; the frame squared up and the guides bored out at same time so that they may be in line with the cylinder. The steam chest is underneath. The steam chest is pierced

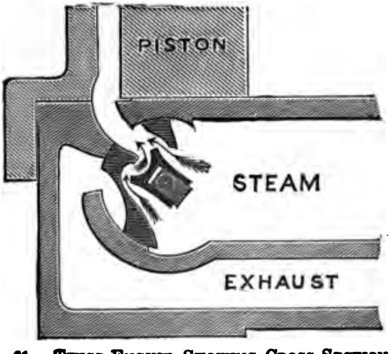

FIG. 61. TWISS ENGINE, SHOWING CROSS SECTION OF VALVES AND PASSAGES.

at each end, directly under the cylinder bore, for four circular slide valves; there being at each end one main valve and one cut-off valve. The main valve admits and exhausts the steam, and the cut-off valves, which are inside of the main valves and concentric with it, have a double opening. The main valves get their motion by drivers, having hollow stems passing through long bonnets secured to the steam chest; to these stems cranks are keyed. These cranks are connected together by a pitman, which receives its motion from an eccentric on the main shaft; and on the larger sizes the eccentric rod is made to disengage, by which means the engine may be worked forward or backward by hand. The cut-off valves get their motion by stems which pass through the hollow stems of the main valve drivers, to the ends of

FIG. 62. TWISS VALVES.

which the cranks are keyed. These cranks are also connected together by a pitman, and receive their motion from another eccentric on the main shaft. As now made, the valve gear is positive closing.

Q. What makes the Twiss engine automatic?

A. A link is interposed between the eccentric and the cut-off valves, and the link block is so attached to the governor that when the balls are raised and lowered, the link block will be moved towards and from the centre of oscillation of the link, thus effecting an earlier or later cut-off.

Q. What is the range of cut-off?

A. From zero to five-eighths stroke.

THE WATERTOWN ENGINE.

Q. Describe the Watertown automatic slide valve horizontal engine.

A. This engine (see Figs. 63 and 143) has a box-bed, locomotive guides, and separate outboard bearing; chest on the side; fly-ball governor, disc crank. The main valve (see section, Fig. 65) plays on a

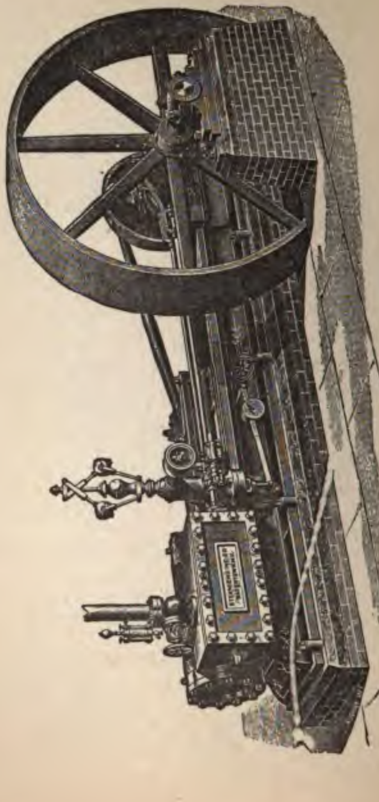

FIG. 63. WATERTOWN ENGINE.

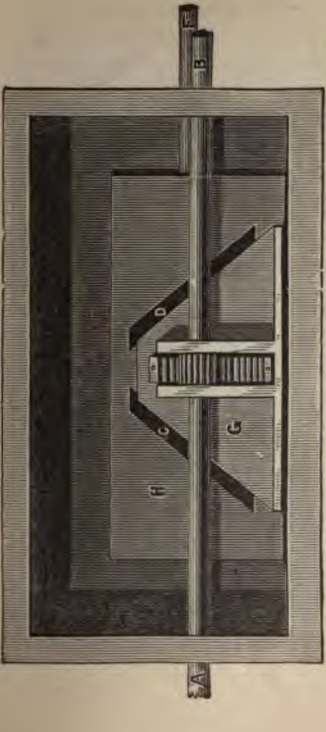

FIG. 64. SIDE ELEVATION, MAIN AND CUT-OFF VALVES, WATERTOWN ENGINE.

three-ported seat like an ordinary "short D" valve, and has its fixed lap, lead, and exhaust closure. It is driven by an ordinary eccentric. Through it pass steam passages which on its back take a diagonal form (see *C*, *D*, Fig. 64). Riding on the back of the main valve is a trapezoidal cut-off valve, on the back of which is a rack engaging a pinion on the cut-off rod *B*, which is operated by a second and independent eccentric on the main shaft. This eccentric has no lead and follows the main eccentric. Rotation of the rod carrying the cut-off valve, raises or lowers the valve, thus closing or opening the steam passages. The governor is a "fly ball," with crossed arms. On the bottom of its stem is a vertical rack which engages a segment on the cut-off valve rod. Increased shaft speed raises the governor stem and closes the steam passages through the main valve.

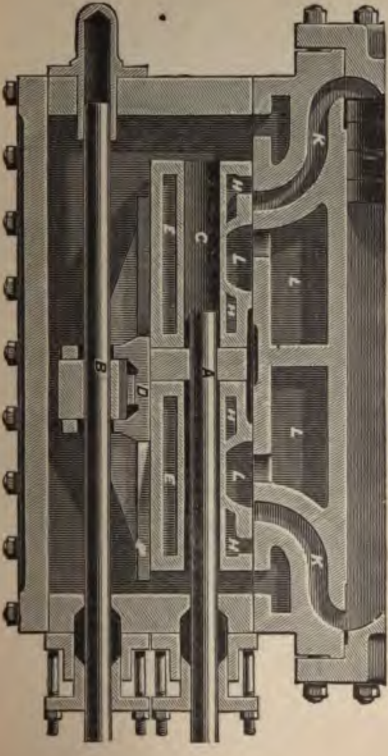

FIG. 65. WATERTOWN ENGINE, HORIZONTAL CENTRAL LENGTHWISE SECTION.

THE WHEELOCK ENGINES.

Q. What are the leading features of
Wheelock plug valve engine?

A. There are two plug valves across a
below each end of the cylinder (see Fi

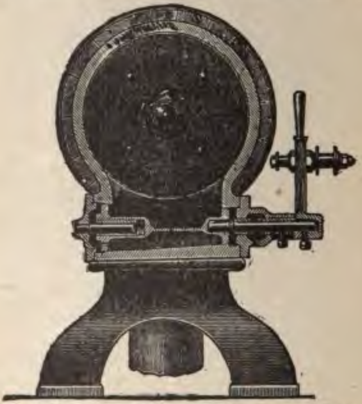

FIG. 66. WHEELOCK ENGINE, CROSSWISE VERTI
SECTION THROUGH MAIN VALVE.

66, 67, and 69). The main valve, wh
admits and exhausts steam, plays upon
admission and an exhaust port in a cyl

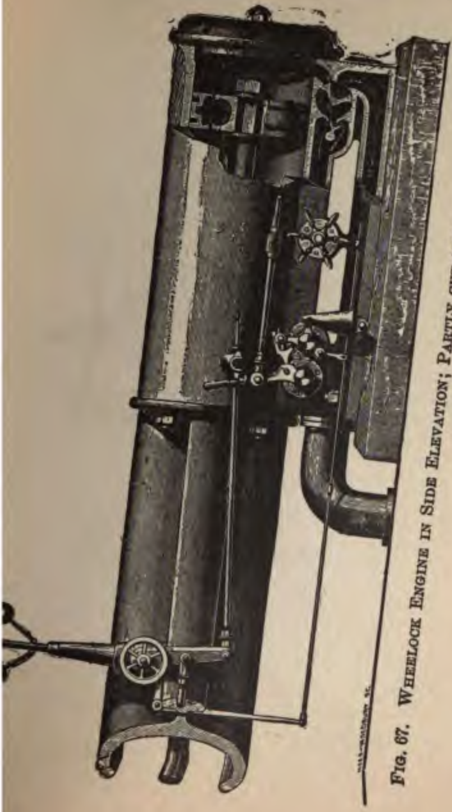

FIG. 67. WHEELOCK ENGINE IN SIDE ELEVATION; PARTLY CUT AWAY TO SHOW VALVES.

drical chamber. There is but one port in each end of the cylinder. The cut-off valve plays upon a seat in the side of this chamber, into which it admits steam from the chest. The main valve gear is an ordinary eccentric rod, disengagable by the engineer. The cut-off is worked from the main valve

FIG. 68. WHEELOCK THROTTLE, LENGTHWISE CENTRAL SECTION.

crank. The valves are hung on trunnions and are adjustable endwise to take up circumferential wear. The throttle valve (Fig. 68) is beneath, and the steam presses it to its seat. The frame is of the girder type, with crescent-formed slides. There is a fly-ball governor.

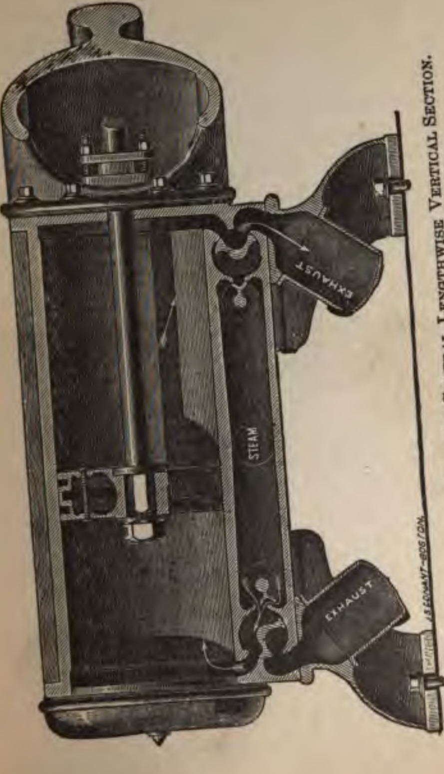

FIG. 69. WHEELOCK ENGINE, CENTRAL LENGTHWISE VERTICAL SECTION.

Q. What is the principal characteristic of the "new type" of Wheelock engine?

A. The valve, which is a flat slide, very narrow in the direction of its throw (which is short), and playing on a gridiron seat, being given its motion by a knuckle-joint. The valve and seat are pushed into cylindrical boxes underneath and athwart the cylinder (see Figs. 70 and 71.)

FIG. 70. CROSS SECTION, WHEELOCK NEW CUT-OFF VALVE.

FIG. 71. WHEELOCK "NEW TYPE" VALVE AND SHELL.

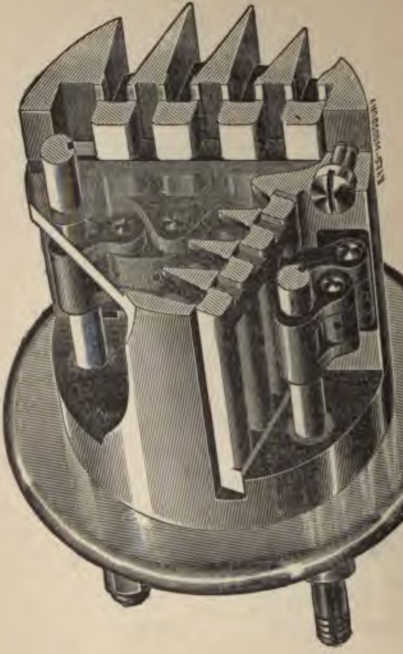

FIG. 72. NEW TYPE WHEELOCK CUT-OFF VALVE.

THE WESTINGHOUSE "STANDARD" ENGINE.

Q. What are the leading features of the Westinghouse "Standard" engine?

A. It is single-acting, duplex, vertical,

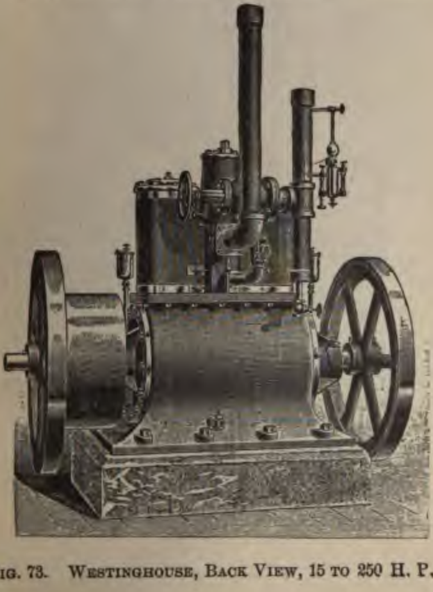

FIG. 73. WESTINGHOUSE, BACK VIEW, 15 TO 250 H. P.

taking steam only at the upper end, and running at high speeds. The pistons are of trunk form, open below and carrying wrist pins *bb*, Fig. 75. The crank shaft bearings

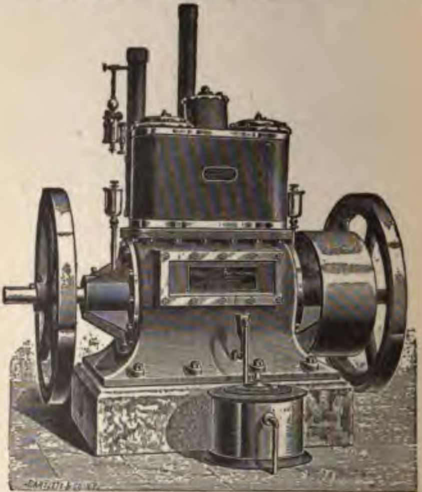

FIG. 74. WESTINGHOUSE, FRONT VIEW, 15 TO 250 H. P.

are removable babbitt-lined shells *dd*. The valve *V* is a piston, playing in a removable bushing. The valve guide *J* serves in lieu

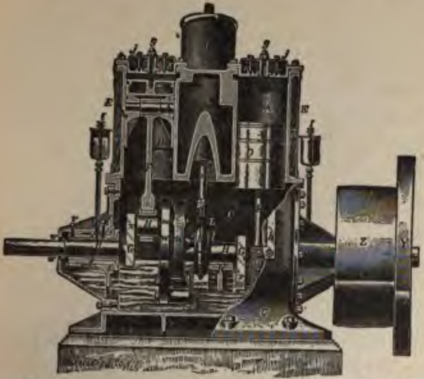

FIG. 75. LENGTHWISE VERTICAL SECTION, 15 TO 250 H. P. WESTINGHOUSE ENGINE.

FIG. 76. WESTINGHOUSE POP-OFFS, 5 TO 35 H. P. ENGINES.

of stuffing box against the exhaust steam in the passage above it. Water is supplied to the crank cap and oil floats thereon for lubrication of the crank pin. *Q* and *R* are steam and exhaust connections. The gov-

FIG. 77. WESTINGHOUSE POP-OFF, 45 TO 250 H. P. ENGINES.

ernor (Figs. 78 and 79) is on the shaft, between the cranks. The disc *A* is keyed to one of the cranks; the loose eccentric *C* is suspended by the arm *c* from the pin *d*. *BB* are the governor weights, pivoted on the pins *bb*; one of the weights being connected to the eccentric by the link *f*, and both weights connected by the link *e*. Coil springs *DD* act against the weights. The eccentric encircles the shaft *S*. The stops

ss limit the motion of the weights. Fig. 79 shows the governor weights at rest; Fig. 78 at earliest cut-off. Pop-off valves, Figs. 76 and 77, save the heads in case of water working over too fast.

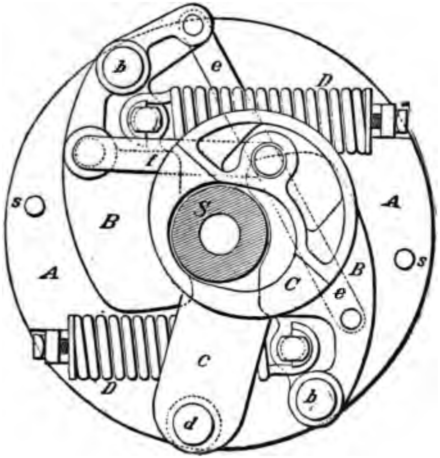

FIG. 78. WESTINGHOUSE GOVERNOR, POSITION OF LATEST CUT-OFF.

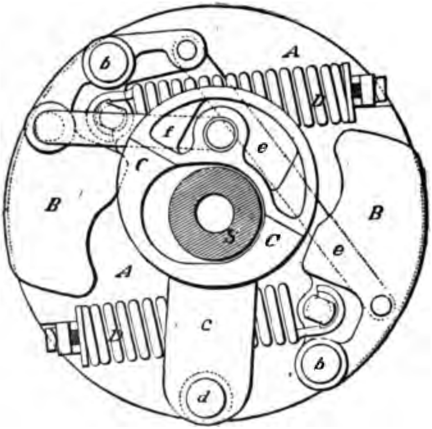

FIG. 79. WESTINGHOUSE GOVERNOR, POSITION OF EARLIEST CUT-OFF.

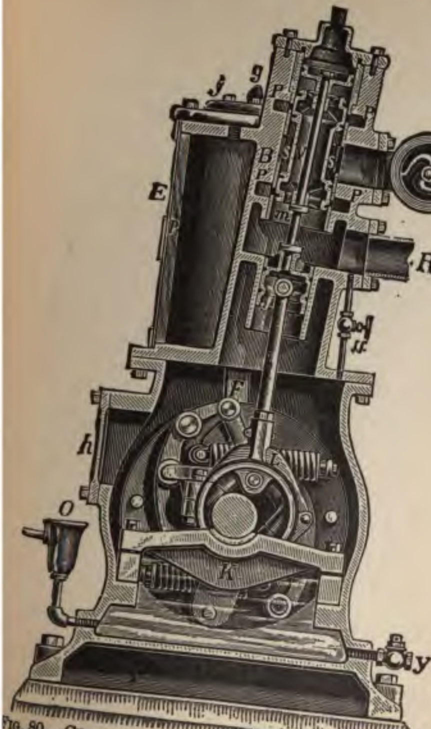

FIG. 80. CROSS SECTION THROUGH VALVE, 15 TO 250 H. P. WESTINGHOUSE ENGINE.

THE TREMPER CUT-OFF.

Q. Describe the Tremper cut-off, such as is used on the engines built by the Pusey & Jones Co., and by the Beckett & McDowell Manufacturing Co.

A. *G*, Fig. 81 is the lower end of the governor ball stem, which is securely fastened to the wedge *W*; *L L* are the lifters; *C* the bell crank, which is operated by a connection

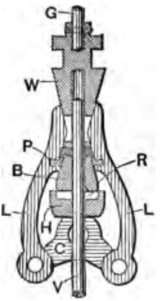

FIG. 81. CATCHER OF TREMPER CUT-OFF.

with the eccentric rod or any convenient place; *V* is the valve stem, to the upper

FIG. 82. TREMPER CUT-OFF.

end of which the beater *B* is attached, the lower end being attached to the cut-off valve shown in Fig. 83. The movement of the beater is identical with that of the valve. The connecting rod before referred to imparts a rocking motion to the bell crank, which moves the lifters upward and downward, alternately, a given distance. The hardened steel plates, fitted into the lifters, project far enough to engage with corresponding plates, in the beater. When the cone or wedge *W* is permitted by the governor balls to rise to its full height, one of the lifters will carry the beater upward, opening the cut-off valve; and as the steel plates are not, under these circumstances, disengaged by the wedge, the valve will remain open until it is closed by following the lifter in its downward movement; it is then re-opened by the lifter on the opposite side, which represents the return-stroke of the engine piston. Under these conditions, the engine carries *full stroke.*" The steam is not being cut off any earlier than is done by the slide or other valve in the steam chest, *but is* admitted to both ends of the cylinder,

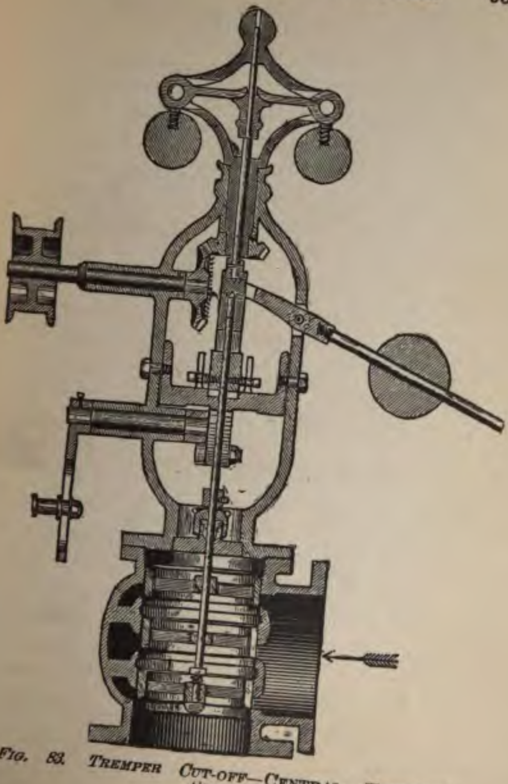

FIG. 83. TREMPER CUT-OFF—CENTRAL VERTICAL SECTION.

FOUNDATIONS.

Q. What is the easiest bottom on which to build a foundation?

A. Rock; the next easiest, what may be called a "general" bottom.

Q. What is the first thing to be done on a "general" bottom?

A. Dig out about 1½ feet below the engine foundation proper, level it off, sprinkle with water, and tamp with a rammer; then fill in 3 inches of gravel and ram that, and so on by 3-inch layers well rammed, until the 18 inches are filled.

Q. What should be the dimensions of this gravel bed?

A. About 2 to 3 feet larger each way than the area of the foundation proper.

Q. What follows the gravel bed?

A. Brick courses, say five layers, "battered" up to the dimensions of the foundations proper.

Q. What is the most unfavorable kind of bottom?

A. Quicksand.

Q. How may this be handled?

A. By driving down small stones by a 2-ton rammer, falling 10 to 25 feet.

Q. Is there any other way?

A. Yes; the most common way is to drive in sheet piling around where you want to dig, driving down further as you dig down; and to put in a bed of concrete made with hydraulic cement, and brick bats or broken stone.

Q. Why not use crib work?

A. If one side or corner goes down it carries the rest with it.

Q. What is the best mortar to use in brick-work for engine foundations?

A. Cement and sharp sand, equal parts.

Q. Should any special provision be made for the foot pieces of the engine (if there should be such foot pieces instead of a continuous box bed) to rest on?

A. It is well to provide special granite bearing pieces for these foot pieces, as well as for the foundation bolts.

Q. What arrangement should be made to ensure the proper position of all bolt holes?

A. A wooden templet of boards 6 x 1 inches, with all bolt holes made therein, should be sent by the engine builder before the foundation is begun, and should be suspended above the foundation so that the bolt holes can be located, and kept centred as the foundation is built up, by means of plumb-lines dropped from the holes in the templet.

Q. Suppose no templet is received, only a drawing accurately showing the position of bolt holes : what can be done in order to ensure that the latter come right ?

A. Either make a templet from the drawings, or go to work as follows :

Establish the centre line of the shaft on the side wall of the engine room ; mark this plainly ; run a horizontal line on the wall through this; plumb down from this and draw another line parallel thereto; take perpendicular offsets from this line, at such a horizontal distance from the centre line and from each other as to pass through where the bolt holes should come ; measure on these offsets horizontal distances of the bolt holes from the line and from each other, so as to locate the bolt holes. Prove

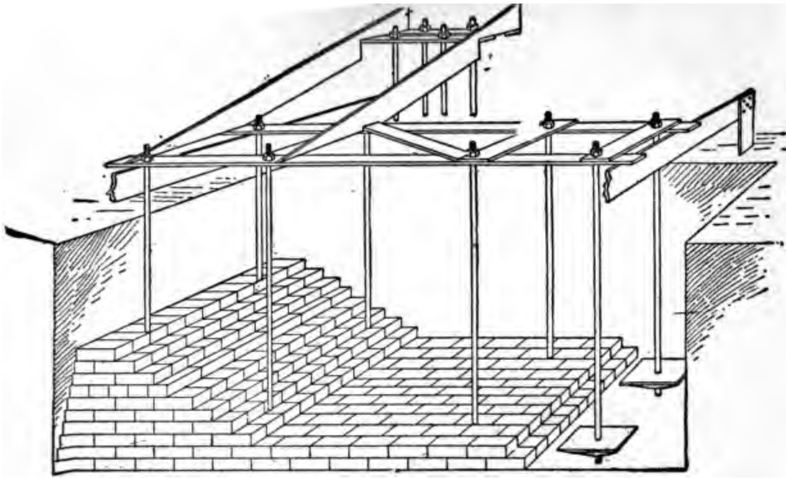

FIG. 84. TEMPLATE AND FOUNDATION, ATLAS ENGINE.

the work by diagonal lines from bolt-hole position to bolt-hole position.

Q. Is there no better way than this?

A. Yes; make a rectangular board frame, and stretch lines across it, parallel to its sides, at such distances that they shall intersect over bolt-hole centres.

Q. What provision may be made for errors in bolt position, and to keep the bolts from touching the masonry?

A. Make short, stout wooden boxes or pipes, about 3 inches square inside; build around these and pull them up as the masonry rises.

Q. How about provision for the flooring?

A. There should be built into the masonry, at proper heights, pieces of joist to carry the regular floor joists; or places should be left for the ends of the latter.

Q. What precaution is found desirable in setting the cap stones?

A. To leave them nearly ¼ inch too high, and dress them off just where the foot pieces come.

Q. How are these dressed down to level?

A. Take a 3-foot level, a 14-foot straight edge, a bush hammer, and some 2-inch cubical blocks, to act as rests for the levels; bush down one place about 2 inches square; then another at the greatest possible distance therefrom; see that the bottoms of these places are at the same level; then bush down other distant places; then establish the levels of nearer places, and so on; and finally dress out between these trial places, to the required areas and outlines.

Q. How should the cement and sand be mixed?

A. Dry, and in small quantities, and the necessary water added when needed; else it will "set," and be of no use.

Q. What is a good way to lay up the brick foundations?

A. Lay the brick in ordinary mortar, following the outline of each course like an 8-inch or 12-inch wall; then lay the brick in the middle portions dry, and grout in very thin cement mortar; doing this two courses at a time, and not forgetting to "bond" the outer portions with the inner.

Q. What would be a quick way to facilitate getting a foundation ready, where one

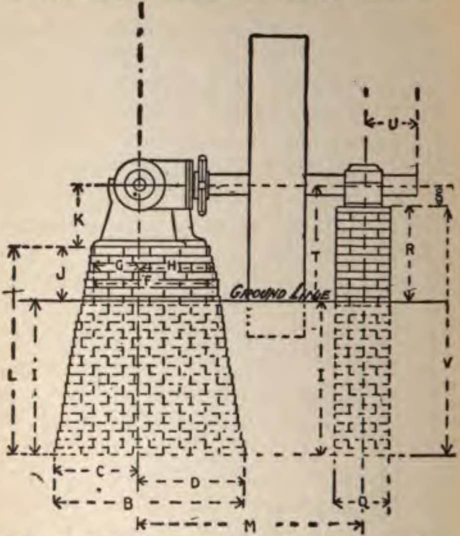

FIG. 85. FOUNDATIONS ATLAS ENGINE, END ELEVATION.

engine was to be taken out and another one to take its place?

A. To make the foundation, except at

and near the top, of rubble, and to put the stones together roughly without mortar,

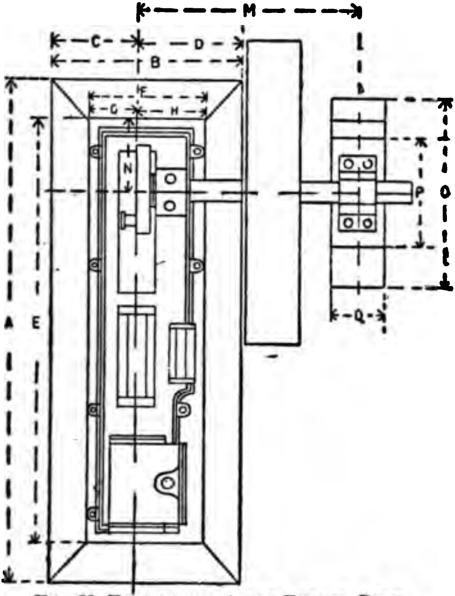

FIG. 86. FOUNDATIONS ATLAS ENGINE, PLAN.

and mark them, before stopping the old engine.

Q. In making the foundation, suppose ledge or hard pan cannot be reached: what should be done?

A. If near water, digging should be done below water level, if that is not too far to be practicable; then lay a timber platform, on which put a layer of concrete or beton, having double the area of the engine floor space, and strong enough not to be cracked by the mass of foundation and the engine itself. Then lay on this the foundation proper of brick or stone, as desired.

Q. Should the jack shaft have a separate foundation?

A. No; it should be borne by the main foundation.

Q. Is it advisable to set an engine foundation on plank when there is water on the bottom of pit?

A. No. Use large stone at the bottom, laid in hydraulic cement.

ERECTING AND STARTING.

Q. Who should do the erecting and starting of an engine?

A. The builder, who should keep control of it until it is formally accepted by the purchaser.

Q. Does this take away from the purchaser the responsibility or duty of inspecting the foundations and setting from the very first?

A. No; if he passes a fault without protest, he should stand by it.

Q. Before putting up the engine, what inspection should be made of the cylinder?

A. It should be wiped out with care and searched all along its bore for patches or plugs or for holes; then the bore should be gauged from one end to the other.

Q. Should a variation in cylinder diameter be passed?

A. A slight barreling or hour-glassing may be passed if the bore is circular in every cross-section.

Q. What will render patches more readily found ?

A. Washing the surface with a weak solution of sal ammoniac to start rust, which will at once show any difference in the grain of the metal.

Q. Should there be any gaskets or similar packing allowed for "permanent" joints; that is, those which do not have to be broken for inspection or repair ?

A. No ; such joints should be made with red lead well stiffened with black oxide of manganese.

Q. Before starting up what is a good thing to do as regards the joints ?

A. To let just a little steam in through the engine for a day or two to bake all joints and set them well before they get strain upon them.

Q. What special precautions should be taken in starting up large engines ?

A. To start them only after the cylinder has been thoroughly warmed.

Q. What class of engines is it specially needful to start very slowly ?

A. Those which have a cylinder jacket

with live or exhaust steam in it; as otherwise they are liable to be cracked by unequal expansion.

Q. In starting up a new Corliss engine, is it advisable to work the wrist-plate motion by hand so as to run the engine backward and forward?

A. No; if there are any quarter turn or twist belts they may be thrown off by this operation; or belts may be on loose pulleys and may run valuable machinery backward, to its detriment or ruin.

Q. How can you show the irregularity of motion of the fly wheel of a large engine?

A. By covering about a foot of the length of the shaft with paper, smoked over its entire surface; arranging a tuning fork making about one hundred vibrations per second, so that a light point on the end of one of its prongs will touch the surface of the smoked paper, while at the same time giving the fork a uniform motion in the direction of the axis of the shaft; thus the vibrations of the fork when struck and applied to the paper, will be recorded upon it during several revolutions of the shaft. The

irregularity may be measured by counting the number of vibrations in any given lengthwise space around different parts of the shaft.

Q. Is it to be recorded as a bad sign if very large engines pound in the bearings and pins of the connecting rods at the beginning of each stroke, when first set up?

A. No; because any large piece of machinery running at slow speed will need to be run rather loosely at first until the parts wear closely to the proper dimensions and shape, when they can be adjusted and the lost motion taken up.

Q. How can you test whether or not a shaft lies fairly in its bearings?

A. By rotating it entirely dry. Brightened rings will show what parts of the journals have found bearings, and on lifting the shaft bright spots on the babbitt-metal will show where these bearings wear.

Q. When an engine is stopped, what should be done?

A. It should be wiped clean all over where it has not been possible to wipe it while running; all bearings and parts should be

examined to see that they are in good condition; and all oil cups filled and seen to be in working order; if not in such condition they should be put right.

Q. If there is an independent condenser, with air pump, should that be started before or after the engine?

A. Before; that can be done while the engine joints are baking.

Q. In starting up should the engine be run slowly or fast?

A. Very slowly for quite a while and the bearings watched closely the while.

Q. If the journals are not round, and should run warm, how may they be brought into shape?

A. By running slowly with the caps off for a while, gradually increasing the speed.

Q. Before putting the full load on, what should be done with the cylinder?

A. The head should be removed and the bore examined; or the ports at one end blocked with soft pine wood so that the engine can be run for a few moments with one head off to test the piston packing; then after the head is put on the engine may be

run full speed without any load, then full load put on slowly, then full load with full speed.

Q. Can an engine be correctly lined up by fastening one end of the thread to a stick set up at the crank, and the other end fastened to a centre placed in the "head" end of the cylinder?

A. Many engines can be so lined up correctly enough for all practical purposes, if the person doing it is a competent practical mechanic.

Q. What are the details of the operation?

A. "Make an accurate centre for the forward or plain head of cylinder with centre line drawn through the stuffing-box, place the wrist-pin at outer end of the stroke, fasten the opposite end to centre of wrist-pin, placing line on a level with centre of shaft. With a pair of inside calipers note how the centre line is located in the chamber of the stuffing-box at cross-head end of cylinder; whether it is in centre or to the right or left. If the line is in the centre at outer end of stroke, then turn the crank to the inner end of the stroke and

try again, being careful in both instances to have the line exactly in centre of wrist-pin. Then again measure position of line in stuffing-box chamber. This will prove whether the shaft is at a right angle with the line of engine or not. If not at a right angle, square the shaft first. Then after that is accomplished, put the crank on outer end of stroke on level with centre of shaft and line up cylinder and guides accordingly."

Q. How can you find the dead points?

A. Key up reasonably tight on the main bearings and the connecting rod ends; turn the engine over until the cross-head is a few inches from the stroke end; scribe the slides and guides so as to fix this point and also scribe the fly-wheel rim, or tram it, in relation with some fixed point on the frame or foundation; turn the engine over past the centre until the scribe marks on slides and guides can correspond, taking up the lost motion in the same direction as before; mark the corresponding point on the fly-wheel rim, in relation with the same fixed point as before; evenly divide the distance

between these two marks on the fly wheel and bring the point of division to the same point where the other two scribe marks were. Get the other dead point in the same way at the other end.

Q. How can you make the permanent clearance marks on the slides?

A. Disconnect the main rod and bring the piston up against the heads; and if the piston rod screws into the cross-head, there should be scribe marks made upon the two pieces, as the clearance marks are of use only when the rod is screwed into the cross-head exactly as much as when these marks were made.

Q. Where engines are upon an upper floor, what precaution must be taken?

A. Not to let them have the same number of revolutions, or any number which will not be "prime" to each other. Thus you may have two engines running 260 each, and they will shake any building; but let one run 259¾ and they will not keep step; in fact, it will be 1040 revolutions of the faster one, between the times when they make their strokes together.

Q. How would you line a beam engine afloat?

A. First draw a line from the bottom of the cylinder, and central with it, to a yoke fastened to the end beam pin. Next draw a line from a similar yoke on the beam-pin connecting rod end to the bottom of the boat, passing the cranks between the ends of the shafts. Sight this line out of wind with the line through the cylinder.

Q. How else may the central position of this line be determined?

A. By placing the crank on the top centre, then on the bottom, noting the error, if there be any, and dividing this error.

Q. If after this line has been adjusted the crank swing out of truth, what must be done?

A. The outboard end must be raised or lowered to strike the line central with crank pin both top and bottom.

Q. What next?

A. Draw a line fore and aft above the top of the cylinder, intersecting the vertical lines through cylinder and between cránks. Now draw a line fore and aft above the

centre of the shaft, intersecting the line between cranks and sighting out of wind with the upper fore and aft line.

Q. How are the shafts to be lined?

A. The driving crank must be turned from the top centre to the bottom centre, also to the half centres and the outboard end of shaft adjusted to make this crank pin strike central both top and bottom, also fore and aft with the lines.

Q. How is one to line the drag crank?

A. By taking a two-foot try-square, placing it against the face of the driving crank, the blade extending across the drag crank, on which a line is scribed; then turning the cranks on the opposite centre and applying the square from the same points. If the square lines with the scribe line, the cranks are true with each other and the shafts are of the same heights. This same test should be applied on the half centres as well.

Q. How is the working beam to be lined?

A. We have now a line central in the cylinder, and one also central with the cranks. Should they not strike the centre line of the yokes on the beam pins, it will be seen at

once that the beam should be moved bodily to one side or the other, or the port or starboard pedestal either forward or aft; keeping the vertical lines out of wind at the same time.

Having the beam lined fore and aft, to line it horizontally—first put the cylinder end of the beam on the top centre, then on the bottom centre, trying the lines at each point: if the line keeps true with the centre of the cylinder, the beam pedestals are correct. If the beam shows by this trial to cross the line, the port or starboard pedestal should be raised or lowered to suit.

Q. How are the guides then set?

A. By the centre line, by trying top and bottom.

VALVE SETTING.

Q. How would you go about it to set a link motion marine engine?

A. Block the valve at its centre of motion; adjust the valve down so that when the valve is at mid-travel the stem shall be so too. Turn the eccentric so that its belly shall line with the link-block centre. If the link has the rods attached to its ends, adjust the rods to a length equal to the distance from the strap to the pin centre, plus half the eccentric throw. Connect the link and receiving gear; put on top centre; turn the eccentric until the valve has the right lead in full gear of either motion. Put on the bottom centre and see that the lead is the same in full gear of either motion, at that end as in the other centre. If the lead is not equal, adjust the eccentric rod lengths until half the difference is taken out, and ship the eccentrics for the other half.

Q. How would you set the main valve of

a slide-valve marine engine, having a rock shaft, indirect hook motion, and riding cut-off valves, adjustable at different points by sword arrangement operated indirectly?

A. Put the main valve at mid-travel, block it there, adjust the valve-stem length so that the rock-shaft arm shall be at right angles with the centre line of the engine. Turn the throw of one eccentric in line with the centre of the eccentric-hook pin. Adjust the eccentric rods to a length equal to the distance from eccentric strap to hook-pin centre, plus half the eccentric throw. Hook the forward motion eccentric in gear. Put the engine on the top centre. Shift the eccentric backward to give the required angular lead. Fasten the eccentric. Do the same thing with the backing eccentric, in the other direction. Put the engine on the lower centre. If the lineal leads are not equal, adjust the eccentric rod one half the difference and move the eccentric to adjust the other half.

Q. How would you set the riding cut-off valve in the foregoing case?

A. Block the cut-off valve at its centre

of motion, leaving the connecting-rod clutch loose on the stem. Block the sword arm at its centre of motion, so that if the head be moved on it, the clutch will not be moved on the valve stem. Turn the belly of the cut-off eccentric in line with the rock-shaft arm pin. Adjust the cut-off eccentric rod to a length equal to half the throw of the eccentric plus the distance from the strap to the pin. Put the engine at the shortest point at which you may wish to cut off. Slide the head on the sword arm to its greatest limit of motion; turn the cut-off eccentric towards the belly of the go-ahead eccentric until the back port in the main valve is closed. Turn the engine until the piston is in the same position relative to the other end of its stroke, and see if the front port of the main valve is closed. If not, adjust the cut-off eccentric-rod length for half the amount of difference, and shift the eccentric for the other half. This sets the valve for that extreme point of the cut-off, and for that point only. (To equalize it for all points is impossible.) Now turn the engine to that point at which cut-off will be

most frequent, move the sword-arm head towards the rock shaft until the main valve port is just closed; scribe the position of the valve-stem clutch; turn the engine to the same piston position at the other end of the stroke; move the sword-arm head until the other main port is just closed; unscrew the valve-stem clutch, and run the valve just half the difference of the two sword-arm positions and refasten the clutch.

Q. What is the first thing to do in setting beam-engine valves?

A. Assuming that the rock-shaft arm is keyed on to the rock shaft in its proper relation to the centre line of motion of the eccentric rod, and that the wipers are keyed on to the rock shaft, in their proper relation to the rock-shaft arm, which is always the case in properly constructed engines,— the first step is to ascertain the proper length of the eccentric rod.

Q. What is the most convenient starting-point for doing so?

A. From the centre of motion of the valve gear.

Q. How do you set about this?

A. Set and hold the rock shaft at the centre of its motion.

Q. When is this?

A. When the lifting rods are down, the valves seated, and the lifting toes adjusted the right distance from the rock shaft, and straight with each other, so that the ends of both wipers will be the same distance from their respective toes.

Q. What are the next steps?

A. Next, put the main crank on the centre, and turn the belly of the eccentric directly in line towards the centre of the eccentric-hook pin; make a fine prick-punch mark on the edge of the pin, and one on the edge of the hook strap, and set a pair of compasses corresponding to the distance between those marks, and measure it. Add to that distance half the throw of the eccentric; reset the compasses to that length, and move the eccentric until the prick-punch marks and compasses again correspond, and adjust the length of eccentric rod so that the hook will just engage the eccentric-hook pin while the eccentric

is held at that position; then slack up the rock shaft so that it can be moved, hook on the eccentric rod, and turn the eccentric in the direction to raise the required valve until it has the proper lead; then (if the engine is of the style that has two eccentrics and two rock shafts), proceed in the same manner with the exhaust-valve gear, and the valves are set.

Q. How do you prove the accuracy of adjustment?

A. Turn the main crank to its opposite centre, and if there be a difference in the lead, either lengthen or shorten the eccentric rod to make up half that difference, and turn the eccentric to make the other half; fasten the eccentric on the shaft and the valves will be right.

Q. Can there be any general rule given as to how the eccentrics should be placed in relation to the crank?

A. No; as that depends upon the relative arrangement of the lifters, valves, wipers, and rock-shaft arms.

Q. How do you set a direct-acting, hook-

motion, slide valve with riding cut-off valve, adjustable by a sword arm?

A. First find the centre of the main-valve motion by moving it until it just begins to open one steam port, and make a mark upon the cylinder face at the end of the valve, or upon any convenient part that will designate its location at that point. Then move the valve until it just begins to open the other steam port, and measure the distance it has travelled from the mark just made; half that distance is the centre of the valve's motion. Then block the valve at the centre of its motion.

Q. How do you ascertain the exact throw of the eccentrics?

A. Subtract the distance from the shaft to the outside of the eccentric on its short side, from the distance from the shaft to the outside of it on the long side; the remainder is the throw of the eccentric.

Q. How do you ascertain the length of the eccentric connection?

A. Turn the long side, or belly of the eccentric directly towards the hook pin, and measure the distance from the eccentric-

strap to the hook pin; add to it half the throw of the eccentric, and adjust the eccentric connections to that length; then fasten it to the strap and hook it to the pin.

Q. What is the next step?

A. Put the crank pin on its centre nearest the cylinder, and turn the go-ahead eccentric in the direction you want the engine to run, until the valve has the proper lead; then fasten it to the shaft. Do the same by the backing eccentric, except to turn its belly in the opposite direction, and you have set the main valve without having turned the engine.

Q. How do you prove the accuracy of this?

A. Turn the crank pin to its opposite centre, and if the valve has the same lead there, it is correct; but should there be a difference, either lengthen or shorten the eccentric connections to make up half that difference, and move the eccentric sufficiently to make up the other half, and the valves will be correct.

Q. How do you set the cut-off valve?

A. Block the main valve at its centre of

motion, and by it block the cut-off valve at its centre of motion; then block the sword-arm at its centre of motion, which is a position at which traversing the shifting head will not move the valve stem; then fasten the valve on the stem. Next, turn the belly of the cut-off eccentric directly towards the connecting pin in the end of the sword arm, and measure the distance from the pin to the eccentric-strap; add to that distance half the throw of the eccentric; adjust the eccentric connection to that length and connect it on. Next, hook the main valve in gear to go ahead; move the engine to the shortest point at which you wish the steam to follow the piston; move the block out on the sword arm to the extremity of its motion, and turn the eccentric in the direction the engine is to run until the steam port in the back of the main valve is closed, and you have set the cut-off valve.

Q. How do you prove it?

A. Turn the crank to a point the same distance from the opposite centre, and if there be a difference, proceed to correct it

in the same manner as you did the main valve.

Q. Are these rules invariable?

A. No. In setting the valves of some engines it would be necessary to somewhat depart from or change this formula, owing to peculiarities in their build, but it will apply to all engines having the kind of valves that are practically correct in their construction.

Q. What is the usual way of setting eccentric and valve on a slide-valve engine?

A. Take off the chest cover while hot, and adjust the eccentric and the length of valve stem so the valve runs square on the ports, or opens at each end to the same amount.

Q. What is the objection to this method?

A. Too much trouble; besides which the same amount of opening does not always give the same practical lead, on account of difference in the ports and passages; and lead is not always given by setting the eccentric ahead and thus giving a crack or opening to the valve.

Q. In resetting the eccentric so as to

make the engine run the other way, should not the eccentric just be reversed, that is, turned round 90°?

A. No; unless there was no steam lap. If there is steam lap, as there nearly invariably is, it should be turned just as far behind the crank, to run backward, as it was ahead of it to run forward.

Q. Where is the most angular shifting of eccentric required in resetting to run the other way?

A. Where there is little steam lap. We are assuming that the shifting will be done in that direction which will require least angular movement of the eccentric.

Q. What can be said about the custom of giving a valve a definite amount of lineal lead, irrespective of the conditions?

A. Very "rule of thumb." The engineer who gives his valve "a scant sixteenth" lead, no matter what its width or travel, the speed of the engine or the pressure of steam, the point of cut-off or the influence which the steam lead might have on the release or cushion, is working blindly.

Q. What tends to make adjustment of

lead, so as to be the same on both ends, most difficult?

A. A connecting rod which is short in proportion to the crank.

Q, How should the valve position be determinable without opening the chest?

A. By prick punch marks on valve stem and one on the stuffing-box (not on the gland), so that a trammel can be applied to show just where the valve is at each important position.

Q. Suppose the adjustment was purposely changed, what would you do about the prick punch marks?

A. Deface the old one on the chest or stuffing-box, and put in a new one; or put a cross on the new one, or in some similar way show that it had superseded the old one.

CARE AND USE.

Q. What can be said about putting new rod packing in the boxes at the same time as the old?

A. If in order to prevent leakage it is necessary to screw the packing up so hard as to cause undue friction, or to render it likely to cut the rods or stems, the boxes should be cleaned out and packed fresh, and new packing should not be put in the boxes with the old.

Q. Can you recommend a cheap piston-rod packing?

A. Take two strips of strong canvas, each as wide as the stuffing-box is deep, and put between these a strip of rubber of the same width; wind these around the rod, and shove them in the box; do not screw up very hard, as the rubber will expand when heated. The wear will come upon the canvas.

Q. About what may be said to be the life of metallic rod packing for locomotives?

A. Upon the C. B. & Q. Railroad piston rods average 50,000 miles without turning; about .764 inch being taken off, each engine getting about 1,600,000 miles, or at the rate of 32 years' life for the packing.

Q. Upon a locomotive how is the valve rod apt to wear?

A. Elliptical in section; wearing more top and bottom.

Q. What is the great trouble with metallic rod packing?

A. That rods are not generally turned true before the packing is applied.

Q. Should metallic rod packing be lubricated?

A. Yes; either by having a hollow gland and an oil cup, or by a swab; or by both.

Q. What is generally the trouble with steam pistons?

A. Packed too tight.

Q. What does this cause?

A. Cutting of the bore.

Q. How can you test a piston for tightness?

A. To take off the back cylinder-head and give steam in front.

Q. Where will a piston probably leak?

A. On top, if it is a horizontal engine that has been run some time without attention.

Q. If it does so leak, why is it?

A. Because the bottom spring has set and let the piston down.

Q. What precaution should be taken in relation to springs?

A. The bottom spring should be the heaviest, because it has to carry the weight of the piston.

Q. How can you centre the piston?

A. Take a wire filed to a sharp point on both ends, just half the diameter of the cylinder, and centre the piston accurately in the cylinder. Then adjust the bottom spring, or springs, if there is one each side of the centre, so that they hold the piston centrally.

Q. What next?

A. After this set out the springs so that they hold the rings up to the cylinder. If this is in any sort of condition a man ought to be able to shove the springs in with the

end of a hammer-handle and have them tight.

Q. How about the stuffing-box end?

A. It is liable to wear down also, and there should always be a ring, or bush, in the bottom of the stuffing-box to take the wear of the rod.

Q. If this ring is worn oval where the rod goes through, what should be done?

A. Get another, and keep the rod central in the cylinder.

Q. Does forcing rings out against a scored cylinder do any good, so far as preventing leakage is concerned?

A. No. If a cylinder is so badly scored that it can't be kept tight, and the owners won't bore it out, the best thing to do is to make an old-fashioned hemp gasket, braided hard, and pack the piston with that. It will fill the grooves and stop leakage, at all events.

Q. In resetting an engine, what is one of the first things to do?

A. To clean all parts thoroughly; taking off the back head, and taking out the pis-

ton, having driven out the key in the cross-head.

Q. What precaution should be taken with the packing rings in resetting a horizontal engine?

A. The rings should be turned "other side up," so as to bring the "down" side that has been getting the most wear, to the top of the head, so as to equalize the wear.

Q. How may the packing springs be tested?

A. The packing springs may have their elasticity tested by pressing them with a lever.

Q. Should packing rings be run loose or tight?

A. Packing rings should be run as loosely as will permit of their being steam tight under the maximum steam pressure that will be put on them.

Q. How may the tightness of packing rings be tested?

A. By blocking the engine on the top or bottom quarter and opening the throttle. Then if steam escapes at both cylinder cocks the rings are not tight enough.

Q. In setting packing rings how may the piston rod be kept central?

A. By frequent use of calipers, having one point turned out at right angles to the other, or by a hard wood distance piece.

Q. How should the valve position be marked?

A. Before putting on the chest cover the valve should be put in its central position and a mark put on its stem, and a corresponding locating mark on some immovable part of the chest—not the stuffing-box gland.

Q. How may the tightness of a slide valve be tested?

A. The tightness of the slide valve may be tested by blocking the engine in such a position that the valve will stand centrally over the ports, covering them (this can be done by means of the scribe marks); then letting steam into the chest; when, if any steam escapes through the cylinder cocks, the valve leaks.

Q. How may the bearings be "cut" from gum?

A. All gum may be "cut" out from the bearings by the use of coal oil or turpentine.

Q. How may pounding be searched for?

A. Pounding may be searched for by blocking the cross head at mid-stroke, and then working the cross head slightly back and forth, and watching the bearings.

Q. How may pounding be intensified so as to make it more easily found?

A. By giving the engine its heaviest load.

Q. What scribe marks should be made on the guides?

A. When the connecting rod is down the piston head should be shoved up until it touches each cylinder head, and "danger marks" scribed on the guides, corresponding to some mark on the cross-head, so as to show if the piston head is too near the cylinder heads, when all is keyed up.

Q. How may it be shown if the main shaft is out of line with the cylinder?

A. Lay a level across the guides and mark where the bubble stands; then when laid on the main shaft the bubble should stand at the same point (supposing that the level has not been turned end for end).

Q. How may the shaft be tested for squareness fore and aft?

A. By stretching a line parallel with the guides, out past the crank; the distance between the line and the crank-pin collar should be the same on both front and back centres. If there is a crank disc, the distance between that and the line should be the same, fore and aft, no matter where the crank pin stood.

Q. Why is it that better results are sometimes got with throttle only partly open than with it full wide?

A. Perhaps the steam is very wet and the throttling dries it. This question can not be properly answered without fuller particulars being given.

Q. Why should not the lead be changed when cut-off is changed?

A. As there is a certain amount of lead required to ensure smooth running at each speed, and as varying speeds are not desirable in stationary engines, the engine should be set, when hot, with the proper amount of lead for her regular speed; and this lead should not be changed while that speed remains constant.

Q. Should two or more engines exhaust into the same pipe?

A. Where two or more engines exhaust into the same pipe, there is apt to be excessive back pressure in both, or, at least, the one which would naturally have the most back pressure will be apt to increase that in the other. It should be noted, in indicating an engine, whether or not its back pressure is likely to be increased, without any fault of its own, by the exhaust from another engine.

Q. When an engine is stopped, what should be done?

A. It should be wiped clean all over where it has not been possible to wipe it while running; all bearings and parts should be examined to see that they are in good condition; and all oil cups filled and seen to be in working order; if not in such condition they should be put right.

Q. How may priming be shown?

A. By white steam escaping from the drip cocks, etc., and by a dead sound of the exhaust.

Q. What should be done in case of priming?

A. The cylinder cocks should be opened wide and the throttle partly closed.

Q. What is the danger liable to occur from a leaky throttle valve?

A. Enough steam may leak past it to start the engine.

Q. How is a compound engine generally started?

A. By admitting live steam to both the high pressure and the low pressure cylinders.

Q. In coupling an engine up with a water wheel, shouid they be arranged to run at the same speed?

A. No; the water wheel should run a little faster than the engine. Then if there be a light load the water wheel will drive the shaft, and the engine (if it is automatic) will cut off and save steam.

Q. How may the same object be accomplished?

A. By having them both arranged with ratchet couplings, through which each drives the main shaft.

Q. What may be said about tightness of the brasses of the crank pin and cross-head pin?

A. They should be loose enough to be moved endwise with comparatively little trouble.

Q. If a bearing runs cool, is that necessarily a sign that it is running without friction?

A. No.

Q. If a bearing runs hot is that necessarily a sign that it is running hard?

A. No: but it is generally the case.

Q. How would you set about to see what caused pounding?

A. First see that the shaft and wrist pin are in line with the cylinder.

Q. How is this done?

A. Fit the brasses tight to the wrist pin and key up the strap; and then see if the cross-head end of the connecting rod will exactly slip into its place in the cross head, without bending on either side. If it will not, the shaft and wrist pin are not in line with the cylinder. If they are so in one position, then try with the shaft revolved $\frac{1}{3}$

turn. If the connecting rod will not come to its place when the cross head is moved to its proper place, then all are not in line.

Q. What may be said about having a regular overhauling time with an engine?

A. It should never be allowed to get so badly out of repair or adjustment as to require a general overhauling. It should be kept always in good condition.

Q. "We are running a little portable saw-mill engine and are troubled with the brasses heating or knocking. The pin is a little out of round, but the brasses are worn to suit, and are a little tighter at the joints, so we can hardly get them on. Had we better file the brasses inside? Will you tell me how to round the pin?" *

A. The brasses cannot be "worn to suit." The pin is worn "oval" as it is called; that is, flattened in two opposite parts at right angles to the crank centre line, whereas if they were so that they would be flat top and bottom when the engine was on her centres, it would be better. But if the brasses fit when on the centres they will

* Question asked by a correspondent.

bind when on the quarters. If you cannot force out or otherwise remove the pin for the purpose of having it turned true (or better yet, ground true) try draw-filing it. Then put in new brasses, as the old ones will be too large at top and bottom. Of course, if the pin is so badly worn that when turned or otherwise made true again it will not be thick enough to stand to the work and keep cool, there is nothing for it but a new pin. Before doing any machine or file work on the pin, if you can get it to run without knocking, do so, no matter how much it heats, and then try black lead on it, in liberal quantities.

Q. How can I line the driving shaft of a portable saw-mill engine with the cylinder? The cylinder is on top of the boiler.

A. The shaft may be perfectly straight, and yet may be (1) too high or too low, and yet be level; also square with the cylinder centre line; (2) at the right height, and also level, and yet "skewed" across the centre line; or, (3) at the right height, where the centre line cuts it, and square with that

centre line, and yet one end too high for the other.

Take off both cylinder heads; saw out two thin circular pieces of boards, the size of the cylinder bore, and put an awl hole through their centres; disconnect the connecting rod; take it down and remove the piston; put the board circles in the cylinder ends; run a grass line through the cylinder centre, and see that it strikes the crank-pin centres when the crank is on the front and back centres; or if there be a centre mark on the crank cheek, see that the line cuts that.

Test for squareness (1) by a try square; or (2) by 3, 4, 5 rule with a cord (this being based on the fact that every triangle having sides in the proportion of 3, 4, and 5 will have a right angle opposite the longest side); or (3) by seeing that the crank cheeks stand the same with the centre line when on the front centre as when on the back.

The above three tests constitute a set, and are independent of the guides, which should really, in most cases, be assumed as true

with the cylinder bore. If they are horizontal (that is if the connecting rod swings between them and at right angles to them) chock the whole engine until the guides show level; then the crank shaft, if straight, should be level also, and the crank cheeks plumb when on either top or bottom quarter; and a straight edge applied to the crank cheeks when on either outboard or inboard centre, should sight parallel with the *side* faces of the guides (not their top and bottom faces). If the cross head be vertical and swings in the plane that both the guides are in, then the sides of the crank-pin brasses should be at the same distance from the crank cheeks, at all parts of the revolution.

If your engine should be of a design to which the above will not apply, more details should be given. The foregoing covers most portable engines with horizontal cylinders on top of the boiler.

Q. "We wish to increase the power of our engine. The feed water pump is upon the side of the engine bed; the plunger is driven by the crosshead of the engine.

We propose to take off this pump and use independent pony feed pump. How much power do you think that we will gain by doing this? The engine is 12x18 inches, 136 revolutions per minute, and the boiler $4\frac{1}{2}$x13 feet; carries 80 pounds of steam. We wish to increase the speed of the engine to 150 revolutions per minute. How much power will we gain by this, and do you think that 150 turns is too fast for a 12x18 inch engine that is built strong? How much larger governor pulley will it take to make the engine turn fully 150 revolutions per minute? We want to gain 10 or 12 horse power. Do you think that we can do so by taking off direct pump and increasing speed to 150? We will put larger pulley upon main line shaft." [The foregoing question was put to the author by a subscriber to *Power and Transmission*, for reply in the columns of that journal. The following is the reply]:

A. "There is no way of telling, because you do not state any of the conditions of lifting, etc., but we would advise independent feed, because this enables you to keep

the water level where you want it, either extra high or extra low, when the engine is running, and will also enable you to keep the boiler fed in case the engine is stopped for any cause. I do not think that it makes much difference either way in the matter of power, whether you feed by cross-head pump or by independent tank.

Q. How would you set an eccentric without turning the engine to try it?

A. Assuming that the engine is "stationary" and has no rocker arm, take a pair of compasses or dividers (the former preferred because they make a visible mark) and draw upon a straight line a semicircle having the same diameter as the eccentric throw (which is the same thing as the valve travel). Call this the valve semicircle. Draw within this and parallel to it a straight line at a distance from it, equal to the valve lap plus the valve lead. Make another circle having the same centre as the semicircle, but with a diameter equal to the shaft where the eccentric is on it. Call this the shaft circle. Draw a line from the centre of the semicircle, through where the

lap line passes through the semicircle, and cutting the shaft circle. The angle that this line makes, with the diameter of the semicircle, is the angle that the eccentric must be turned through over and above a right angle, ahead of the crank. Divide the shaft into four parts, commencing with the crank line. Step off a quarter circle in the direction in which the engine is to run, from the crank line. Step off from this the same distance as there is between the diameter of the big circle and where the long radius line cuts it. That will be where the belly of the eccentric, or the line passing through the shaft centre and the eccentric centre should come. Of course the measurements must be carefully made and the line carefully drawn.

Q. How would you exactly locate lost motion in the main bearing of an engine, so as to tell at what part of the stroke it commenced, and how much compression to give to counteract it?

A. Use an indicator having a second multiplying lever having a vertical motion only, and bearing a pencil making a trace

underneath, and parallel to, the atmospheric and vacuum lines of the usual "diagram;" this lever being pivoted to a little standard on the connecting piece of the instrument, and the pencil position adjustable in height by a spring and screw, the latter formed on a light rod passing through the connecting piece. Vertical motion of this rod will cause the pencil to vibrate vertically. If the rod is kept at a constant height, the pencil will trace a horizontal line partly around the paper cylinder; but any pull on the rod will make a jog in the tracing.

The main bearing being slacked up, pivot a vertical metal lever to the bed plate, so as to bear against the far side of the main shaft (assumed to be truly cylindrical, and tested for this purpose beforehand). Connect the upper end of this lever by a wire or inelastic cord passing around a guide-pulley to the lower end of the vertical rod on the lost-motion lever of the indicator, and have all slack taken up and held out by the spring on the vertical rod.

It is evident that if the main shaft has

any horizontal movement, it will cause horizontal vibration of the free end of the lever bearing against it, and thus tighten or slacken the cord and produce a vertical movement of the lost-motion lever on the indicator. This will cause a jog, either below or above, in the supplementary horizontal line representing the cross-head path; and will indicate, beyond all question, where the lost motion commences, how long it lasts, in which direction it is from the normal, and when and where it stops.

By the aid of this, its inventor cured a previously incorrigible engine.

EMERGENCIES.

Q. Suppose that a cast-iron steam-pipe breaks across between two "ells." Instead of shutting down and waiting long enough to get a new length, how would you manage?

A. Bind the joint with wood strips sewed well around with stout cord or rope, and prevent endwise separation by more rope diagonally across the break from one reach of pipe to the other. Then when the wood and the cord get wet with the steam the joint will be even tighter than before, because the wood will swell and the cords shorten. (See Fig. 87.)

Q. What should be done for a hot main bearing?

A. Brasses slacked if too tight; graphite and oil run in; if trouble continues, engine should be stopped, all bearing surfaces lined and squared, and wiped clean, and then black-leaded and oiled and started up again slowly.

Q. What should be done for a hot crank pin?

A. Brasses slacked if too tight; olive oil and sulphur run in; if that has no effect, graphite and oil; if that does not do, then all bearing surfaces on journal and brasses

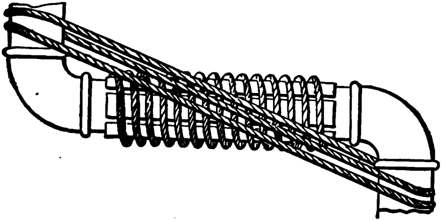

FIG. 87.

wiped; and all squared, fitted, and scraped; then oiled and black-leaded and started up slowly.

Q. What would you do in case the crank pin broke, where the crank had two webs?

A. Drill a hole through it and fasten it with a steel bolt about one third the diameter of the pin; cutting out the webs for the head of the bolt and for the nut.

Q. In case of sudden or unexpected stop-

page of your engine, what would you look to first to learn the cause?

A. The eccentric, to see if it had not slipped; then the valve gear; then if nothing showed wrong I should open the steam chest (if a slide-valve engine) to see if the valve was not disconnected.

Q. How would you know if the eccentric had slipped?

A. Its proper place should be unmistakably marked so that if it had slipped around even a trifle that would be shown.

Q. But suppose its place had not been marked?

A. If the valve had no lap, I should put the eccentric with the highest part just 90° (right angle) ahead of the crank. If there was steam lap on the valve I should open the cylinder pet cocks at the ends, put the engine on a centre and then turn the eccentric still further around, ahead of the position at right angles of the crank, until steam blew through just a trifle; fasten it temporarily; turn the engine over to the other centre and see if the steam again blew through just the same amount; if not, ad-

just the lead by lengthening or shortening the valve stem until there was the same amount of "blow" of live steam on each centre.

Q. What is the object of setting the eccentric so as to give a "blow" on each centre?

A. To give lead.

Q. What would you do in case of a split cylinder cover?

A. If beyond repair, block the valve of that end and work the other end only; reducing the initial pressure.

Q. Why reduce the pressure when you would be running with only half of the engine, and in case of a condensing engine with less effective pressure in that end?

A. Because the pressure upon the crank pin would be too unequal.

Q. It frequently happens that a piece will be broken out of a locomotive cylinder or other casting that can be patched, and the expense of replacing the whole obviated. Give a good method of doing this.

A. "The main casting is cut off inside the crack to a fairly uniform line. A model is

then made by means of the portion cut off to fit over the end of the break and make the necessary junctions with the adjoining parts of the machine. The lower half of the mould flask is fitted around the broken end of the casting and well secured to it, and the joint is sealed with clay. The model is then set into the flask over the broken end, on which, of course, it should lap a certain amount, and the moulding is proceeded with. The upper half of the flask has, of course, a core fitting into the hollow of the broken end, if such there be. Before casting, the broken end is well warmed by a charcoal fire placed within."

ERECTING AND ADJUSTING SPECIAL ENGINES.

THE ARMINGTON & SIMS.

Q. How would you proceed to set up an Armington and Sims engine ?

A. Generally in shipping to all parts of the country the engines are sent forward after being tested, with all parts in place excepting the driving wheel and oil cups. If the shaft is not in, be careful in placing not to screw up the cheek pieces too much, but wait until starting and adjust it to bearing—the caps will be found in place when received ; in removing them be sure to put the liners back as found and the caps can then be screwed down solid. If the regulator wheel is off and the regulator removed, then put the eccentric on the shaft, and put it up so that there will be one sixty-fourth play between end of hub and the eccentric, and then connect as shown in Fig.

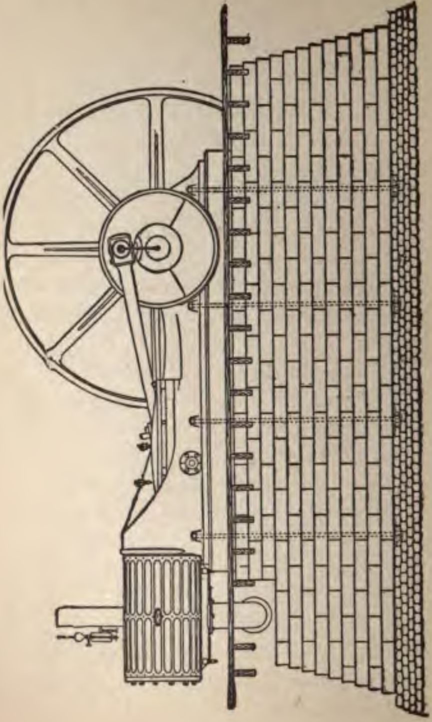

FIG. 88. FRONT ELEVATION, TANGYE PATTERN, BUCKEYE ENGINE.

88, which gives those positions of weights, eccentrics, and links which give the valve its least travel and shortest cut-off. With regulator as shown in Figs. 88 and 89, the

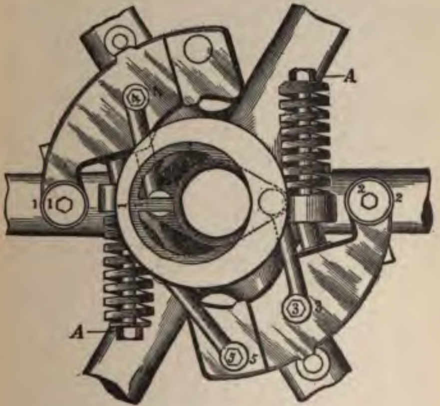

FIG. 88. ARMINGTON & SIMS GOVERNOR, EARLY CUT-OFF.

crank pin should be in the direction of 1. In changing from the short to the long travel, the figures 1 on the eccentrics will diverge until 1 and 2 are together, as will

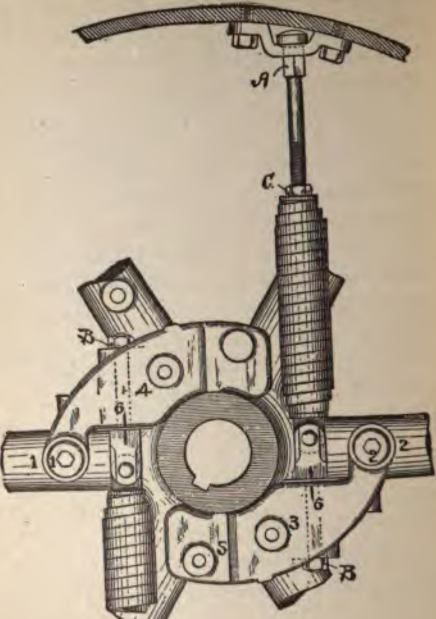

FIG. 90. ARMINGTON & SIMS GOVERNOR FOR LARGE ENGINES.

The regulator with the springs in this manner is to be put together the same as the other, being marked the same, excepting the springs which are attached to the rim of wheel as shown. The jaw that attaches spring to weight has been adjusted to the required speed and is marked as at 6, which marks should come together. The tension of springs and adjustment for speed is by nut *A* same as before, and nut *C* is a check nut—any variation of speed must be made by the alteration of weights as before explained.

Q. How about oil cups?

A. The wiper cups *C* (see Fig. 91) are sent on the connecting rod; the oil cup on the small bracket is to be attached to the slide bar, and the one on the large bracket to the pedestal cap. Adjust the tube by the nut *A* so that the wick will just clear the wiper as near as possible without actually hitting. If from use the wicks get gummed up, put in new

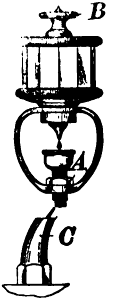

FIG. 91.
WIPER CUP.

ones; not too tight to prevent the oil from feeding, with the small ring attached to prevent them slipping through. Put oil cups on slide bars and on covers of main bearings; also the flat cup on the eccentric strap, and attach feeding cup by bracket to the bed. Attach the two small cups having tube for wick feed to the valve-stem guide, and the two similar cups (without tube) to the regulator weights.

Q. What additional precaution is there to insure the perfect working of the regulator?

A. The makers now drill into the shaft—you will find a brass plug with a hole. Into this inject oil occasionally, which will cause the sleeve to move on shaft without sticking. Use good, thin oil on the regulator.

Q. How would you set the valve?

A. If the distance between *B* and *C* (see Fig. 92) is just three inches, you will know that the valve is all right. If, however, you wish to put in a new valve and adjust, then remove the steam-chest cover and place the engine on the centre as follows: place line marked *A*, which is on the crank pin side, with line on opposite side of rim

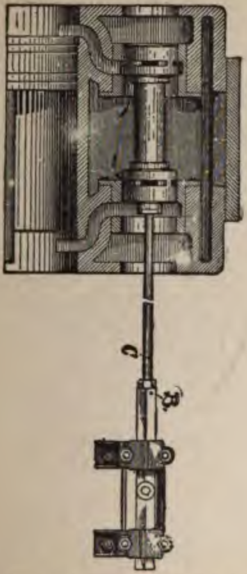

FIG. 92. ARMINGTON & SIMS VALVE.

marked *F* (not shown in drawing), level with engine; now take out, or loosen up, the springs and block the weights out so that the distance between weights and pin at *D E*, Fig. 93, will be three quarters of an

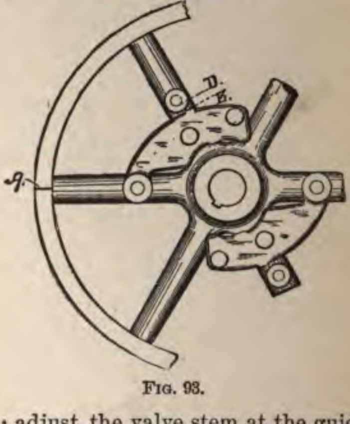

FIG. 93.

inch; adjust the valve stem at the guide so that by turning the engine over from one centre to the other, the lead will be the same at both ports; then make a new mark distinctly on the valve rod so that the distance *B C* will be the standard three inches.

THE ATLAS SLIDE VALVE ENGINE.

Q. How would you proceed to set an "Atlas" slide-valve engine?

A. When the engine has been placed on the foundation,* square it carefully with the shaft it is to drive, take off the cross-head guide caps, place a spirit level upon the guides, and level the engine both length-wise and across by putting under it thin wedges of wood. When perfectly level put the nuts on the foundation bolts and draw moderately tight, being careful to keep level. Then make a bank around the bottom of the bed plate with strips of wood and clay, leaving convenient pouring space, and run melted sulphur under until the space between the engine and the foundation is filled. When the sulphur has had time to cool screw down the nuts firmly. Then put the out-board pillow block on its foundation; take the eccentric out of its straps; put it on the main shaft, and lay the shaft in its place, supporting it by means of

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* See Figs. 4 and 5, pages 13 and 14.

FIG. 94. ATLAS SLIDE VALVE, BALANCE CASE.

king under its middle. Get it square h the engine and level. Set up the quar-

FIG. 95. ATLAS SLIDE VALVE, LENGTHWISE SECTION.

boxes of main bearing moderately tight means of the backing screws; see that

the wooden liners are in place on the tops of the quarter boxes, and put on the cap. Observe that the cap is not to touch the shaft, but bear only on the wooden liners to keep

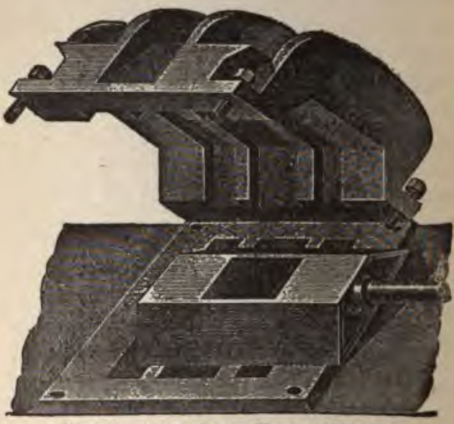


FIG. 96. ATLAS SLIDE VALVE, EXPOSED.

the quarter-boxes down in place. There should never be less than $\frac{1}{32}$ inch space between the cap and shaft, its use being simply to hold the quarter-boxes down and

keep out dirt. The out-board pillow block may now be wedged up to the shaft and sulphured. The band, or fly-wheel, if in halves, may then be put on. If solid, the shaft will have to be taken out, put through the wheel, lowered into place, and the main bearing adjusted as before. The pipe connections may then be made, the doping cleaned off the bright work, and every part of the engine made thoroughly clean. When you have raised steam take off the steam-chest cover, and by opening the throttle blow out any dirt there may be in the steam pipe. Then take off the back cylinder head, and slack off the front head. Wipe out the steam chest clean ; oil the valve seat ; replace the cover ; and, having opened the throttle, work the valve back and forth by hand. This will cause the steam to blow out all dirt there may be in the passages of the cylinder. Having wiped out and oiled the inside of the cylinder, replace the heads ; screw the nuts up tight ; pack the glands ; make the crank and eccentric connections ; oil all the joints, and you are ready to start.

ERECTING A BUCKEYE ENGINE.

Q. Give a full description of how you would proceed to set up a Buckeye engine, if every piece were separated from the others.

A. Buckeye engines are at present built in three styles, which are designated by the builders as "A," "B," and "C," and as slightly different instruction are required in some respects for the different styles, will be referred to as above.

Style "A" is of the girder form with two slides made integral with the frame, and with vertical cross head, the dies of which are adjustable for wear. The engine rests on two feet or pedestals; the one under the shaft bearing, and the other, under and attached to the cylinder. (In some larger sizes a third pedestal is introduced under the middle near the end of the slides.) The body or frame work of the engine thus consists of four pieces, namely, the main frame, the shaft pedestal, the cylnder and its pedestal. These parts are secured together by bolts, and no instructions are needed to en-

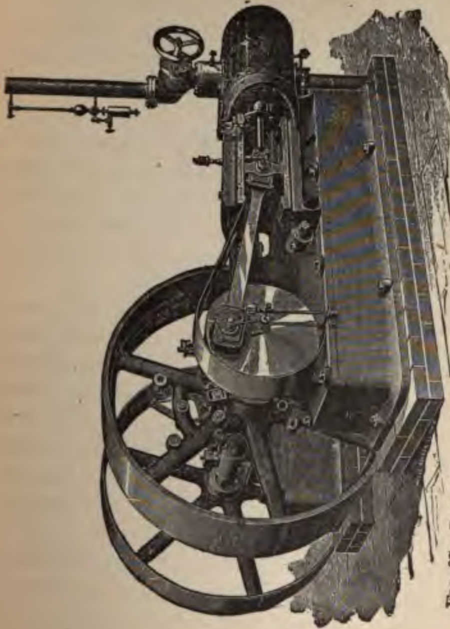


FIG. 97. BACK VIEW, GIRDER BED OR STYLE A, BUCKEYE ENGINE.

able any competent mechanic to put them together.

Style "B" consists as to its frame work of two pieces, the main frame and the cylinder. The former contains one half of the shaft bearing, made integral with it, in small and medium sizes, in which a two-part box is used, parting on an angle of 30° from the vertical; or in the largest sizes the housing of a four-part box. The main part has a sole surface its entire length, but the cylinder overhangs. The slides are four in number and are separate from the frame and acquire alignment in the first place and adjustment after wear.

Style "C," like style "A," has two slides and a vertical cross head, but the slides are separate pieces, requiring alignment and compensating adjustment. Like style "B," its frame work consists of two pieces, the main piece containing one half the shaft bearing integral therewith, and a continuous sole and overhanging cylinder. The following instructions will assume that whichever the style, the parts constituting the main frame work have been put together

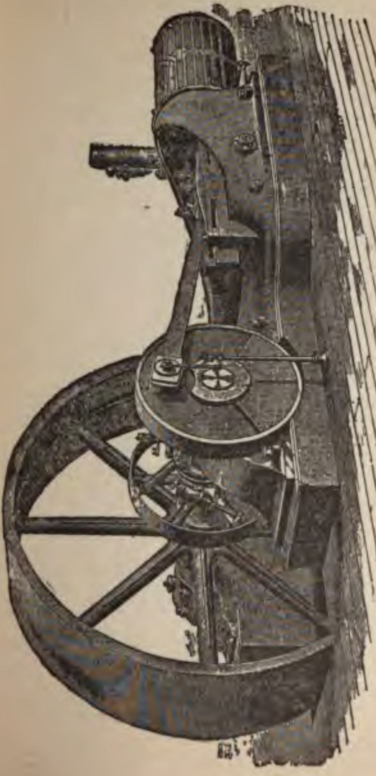


FIG 98. FRONT VIEW, TANGYE BED OR STYLE B, BUCKEYE ENGINE.

and the whole properly set on and secured to the foundation.

In all the styles, put in the main shaft and adjust the outer bearing simply to bring it level and square with the centre line of the cylinder. No adjustment in the direction of its length is provided for, its position in that respect having been immovably fixed in the shop ; hence in style "A" the line for squaring the shaft need not be stretched through the centre of the cylinder, but may be attached to a bit of wood jammed between the inside of the hood and the stuffing box at a point near the latter, and about on a level with the centre, but not necessarily parallel with the central axis of the cylinder, except as to their vertical planes.

Attach it at such a point that it may pass outside of the cross head and crank pin, securing it to some existing or temporarily erected support. Make it parallel with the planed outer surfaces of the slides (which are parallel with the axis of the cylinder) by means of an extemporized gauge consisting of a billet of wood of proper length

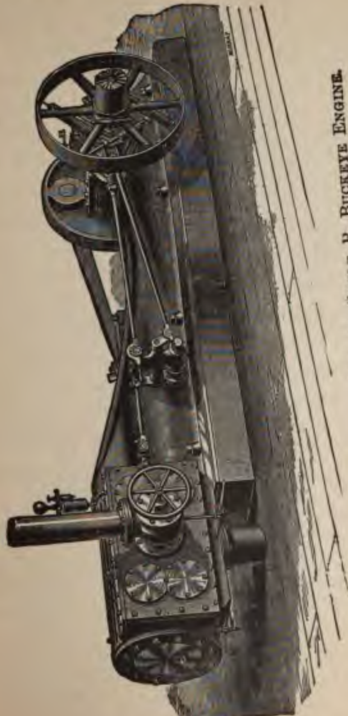


FIG. 99. BACK VIEW, TANGYE BED OR STYLE B, BUCKEYE ENGINE.

with two nails or screws in one e
one in the other so placed as to res
planed surfaces before mentioned, l
feet, while a fourth reaches a
touches the line, which is adjusted
so touched equally at each end of tl
Then take measurements from the
the end of the crank pin at each d
tre, or if the crank is a disc with rin
true, the measurements may be ma
the line to this rim without turning

The same instructions apply to st
except that the slides being separat
can not be used as guides for adju
line, but the edges of the part to w
slides are attached are trued for
pose. As the slides, however, in t
require alignment it may be thou
to stretch the line through the ce
this purpose; but many erecting e
prefer to set them by the cross head
it to and fro and adjusting until i
freely and the rod runs true and
bind the stuffing-box follower in an
tion at any point; a method whic

FIG. 100. FRONT VIEW, HIGH SPEED AUTOMATIC, STYLE C, BUCKEYE ENGINE.

tirely practical with new engines of moderate size.

Style "B" not being provided with any trued surface analagous to those on the others, by which to adjust a line, the cord must be stretched through the centre in the usual way, both for shaft and side alignment. But as only the lower pair of slides can be set while the line is in position, and as the lateral guidance is dependent mainly on the upper pair, that adjustment must be finally tested as above directed, by the movement of the cross head and rod.

The larger sizes of style "B" which have the four-part shaft boxes are also provided with short, small bosses adjacent to the back edge of the periphery or rim of the crank disc; which having been planed true with each other and with the vertical plane of the central axis of the cylinder, serve to test the horizontal alignment of the shaft at any time in a moment by their proximity to the rim; equally at two nearly opposite points when alignment is correct.

The shaft properly levelled and squared, next put together the valve gear, for which

no detailed instructions will be needed. The rocker arm was formerly secured rigidly to its shaft which passed through and worked freely in bearings, but latterly the plan has been adopted of holding the shaft stationary and fitting the arm to work freely on it, it having a side box and set screws to compensate for wear.

Put the eccentric in place against the journal box (as it forms the collar for the journal) ; put on its straps and connect the rod to the outer pin of the rocker arm; adjust its length as provided for at its attachment to the strap so that the arm will vibrate about equally each side of the perpendicular as the eccentric is rotated ; and secure the fastening, noting that the straps are not twisted noticeably out of the perpendicular (a distortion rendered possible by the perfectly spherical form of the eccentric face).

Connect the inner pin of the arm to the valve stem, clamping it in such position that the valve will be at mid-travel when the rocker arm is vertical, but attending to its more perfect adjustment later when set-

ting the valve. Put the governor wheel in place in such angular position that when the parts are in place and the weight arms resting on their inner stops the eccentric and crank will be on their dead centres at the same time and in the same direction.

Q. When the chest covers of a Buckeye engine are removed, what are the openings that appear at the ends like the admission openings of the common slide valve?

A. The exhausts.

Q. Where are the openings for admission?

A. They are invisible, but are indicated by marks on the valve corresponding to the ports, and similar ones on the cylinder in line with the ports. Those on the valve represent its ports at its narrowest part, exclusive of the indentations in their margins to graduate the admission; hence the admission indicated by them is the beginning of full port admission, and not the beginning at the indentations.

Q. What are these indentations for?

A. To soften the shock of admission and insure the prompt attainment of full initial

pressure as soon as full opening is reached. They have the same general effect as lead.

Q. How should the piston travel be equalized?

A. By marking cross head and slides so as to show the dead centres or ends of travel; then disconnecting the connecting rod from the crank pin, and shoving the cross head beyond its travel at each end until the piston strikes; then if the amount of this extra travel is found to be unequal between the two ends, it should be equalized by screwing the piston rod into or out of the cross head as required.

Q. What do these marks show?

A. They serve to measure from to locate any events of the valve function in the stroke, and also as guides by which to correct the length of the connecting rod when such corrections are made necessary by wear of its boxes or the shaft bearing.

Q. Are these marks absolutely reliable as a means of placing the crank on its dead centres?

A. No; the crank may be moved a no-

ticeable amount either way without showing much upon the witness marks.

Q. Then what is the proper way to find the dead centres?

A. By levelling the connecting rod with a spirit level applied to one of its parallel surfaces.

Q. What is the first thing to do in setting the main valve of a Buckeye engine?

A. To see that the main eccentric is in about its correct angular position. If it is an over-running engine it should be placed upon its outer dead centre; if it runs under, upon the inner one. In either case set the eccentric upwards and inclined towards crank enough to place the valve out of its mid-position an amount equal to the required angular advance.

Q. What is the next step, and what is the proper thing to do?

A. To equalize the main valve movement by making the maximum admission openings equal.

Q. Next?

A. Test the set of the eccentric by the leads and compressions.

Q. What is the final test of the equalizations?

A. Comparing the compressions.

Q. Should it be impossible to make the cut-off and compression both equalize, which should be given the preference?

A. The compression.

Q. Suppose the engine is too large to conveniently revolve the whole engine, what should be done?

A. The eccentric alone revolved, and the valve movement equalized by the maximum admission openings.

Q. How can the eccentric be fixed in the right place?

A. By putting the crank on one of the dead centres, and giving the eccentric the lead required in the table which goes with their engine.

Q. How may adjustment by equalization be made?

A. Either by lengthening or shortening the eccentric rod as provided for at its junction with the straps, or by shifting the clamp wrist on the valve stem.

Q. Which of these two is the better?

A. Changing the eccentric rod length, if the cut-off is correctly adjusted, and it is desired not to disturb it.

Q. If not, which method is preferable?

A. That which will leave the rocker arm most nearly vertical at mid-movement.

Q. Should either of these two adjustments be made for any other purpose than equalization?

A. No.

Q. How should all changes be made which require to be equal at the two ends?

A. By shifting the eccentric.

Q. Why is it that the exhaust lap of the valve at the stem end is wider than at the other?

A. To equalize both leads and compressions at the same time.

Q. Why is this?

A. The connection is practically shortened when inclined up or down, hence the piston moves slowest at that end, and more exhaust lap is needed to close the exhaust at a given distance from that end of the stroke.

Q. How would you set the cut-off valve of a Buckeye engine?

A. Set the governor so that its eccentric and the crank will be on their dead centres at the same time and in the same direction; that is, so that the rod of its eccentric will move coincidentally with the piston, and in the same direction. Then block the levers about half-way out, and note where the cut-off takes place as the engine is turned over.

Q. How may the points of cut-off be noted?

A. By removing the balance-ring cover plates.

Q. Suppose you cannot see the final closure?

A. Feel for it with a wire or a strip of sheet metal flattened at the end to a wire edge.

Q. Any other way, without removing the plates?

A. By removing the indicator plugs and letting steam blow through them, and noting the points at which it stops blowing.

Q. Should cut-off take place earlier than one fifth or later than one fourth, what should be done?

A. Change the blocking of the levers tc bring them within these limits ; and ther compare them for equality.

Q. Suppose they are then found to b unequal ?

A. Lengthen or shorten the cut-off con nection so as to throw the valve toward the end at which the cut-off is latest.

Q. Is there more than one way of makin this adjustment ?

A. Yes ; it may be made between th rocker arm and the valve by screwing th rod out of or into the neck of the brass bo (or in case of different construction, as con struction calls for), or at the attachment o the eccentric rod to the straps : choice i that respect being determined by knowin whether the upper arm of the cut-off vi brates equally each way from coincidenc with the pin of the main rocker near it If so, or if adjustment at the straps woul leave it more unequal than before, the first named adjustment should be chosen. (Thi will always be the case when the gear ha to be properly put together.)

Q. Why is equalization about the average working point necessary?

A. Because owing to the unequal piston movement, the cut-off cannot be exactly equalized at all points.

Q. Suppose that they are equalized as above directed, how will they be at earliest cuts?

A. Very much later at crank end than at the other end.

Q. How will they be at latest cuts?

A. Somewhat earlier at crank end.

Q. How can you equalize without turning the shaft?

A. Loosen the governor wheel on the shafting and turn it until the exact mid-travel of the valve can be determined by measurement from some fixed point. Stop it at mid-travel and with the balance-ring cover plates removed, note the position of the cut-off valve with reference to the ports over which it works. Both of them should show partly open, but that at the stem end to show the wider opening by an amount equal to $\frac{1}{12}$ or $\frac{1}{14}$ the valve travel; these

differences giving equality at $\frac{1}{4}$ and $\frac{1}{5}$ cuts respectively.

Q. When the governor has been given its first adjustment as laid down before, where are the latest cut-offs?

A. Those when the levers are resting on their stops; about five-eighths of the stroke.

Q. Where will the earliest cut-offs be?

A. When the levers are at the outer limit of their range—say, inside the first inch of piston stroke.

Q. Suppose such adjustment will not hold the engine from running away, or from too much speed when driving its lightest load under the highest pressure, what adjustment must be made?

A. The governor must be advanced until it will control it; that is, turned on the shaft in the direction that the engine runs.

Q. Under what conditions will this advance generally be necessary?

A. Where a condenser is attached.

Q. Will it ever be necessary to set the governor back of the usual position?

A. Yes; if the engine is heavily loaded

and a considerable part of the load is not liable to be detached.

Q. How should any such adjustment be tested before trusting it to the chances of such conditions?

A. By giving the engine highest pressure and lightest load.

Q. Should the spring tension be varied to effect changes of speed?

A. Only to a very limited extent, and under certain circumstances to be explained later.

Q. How can the spring tension be adjusted so as to get as close regulation as possible?

A. By giving the springs all the initial tension that can be carried without "racing."

Q. What other causes may there be for racing besides too much spring tension?

A. Undue friction about the governor joints, or the loose eccentric on the shaft; lack of oil; gumminess, and rust.

Q. Suppose an engine which has regulated steadily for a time gets to racing without any increase of spring tension or

equivalent adjustment having been made, what is that a sign of?

A. Of undue friction.

Q. What rule for tension may be given?

A. That when the auxiliary springs are applied and properly adjusted, and the levers tolerably heavily weighted, it should be over one half of the leverage of the springs (in some cases as much as six-tenths.)

Q. What do you mean by the leverage?

A. The distance from the centres of the pivots of the levers to the points of attachment of the springs.

Q. When there are no auxiliary springs, how much tension should be carried?

A. About four tenths the leverage.

Q. If the levers are lightly weighted, how about the tension that can be carried?

A. Less tension can be carried, because then a larger proportion of the effective centrifugal weight is in the levers themselves and their appendages, so that the centre of force of the parts is nearer the shaft.

Q. Where are the auxiliary springs used?

A. Where the requirements of close regu-

lation are greater than usual, as in electric lighting, etc.

Q. What adjustment is required to get the full benefit of them?

A. Give them considerable force by reaching well out with the fingers which act on them; to give the main springs as much tension as possible without racing.

Q. Suppose that on starting up the levers start out at much below the proper speed, what should be done?

A. The reach of the fingers should be shortened until very near the proper speed is reached before the levers start out.

Q. If it is desirable to improve the regulation slightly, how may the desired result be attained?

A. By changing either the tension on the leverage, or both: thus supposing that the speed changes a little too much with changes of load of pressure, we may correct the trouble by adding tension or by diminishing leverage (moving the spring clips towards the pivot); or since the former willincrease the speed and the latter diminish it, we may accomplish the desired improvement by such

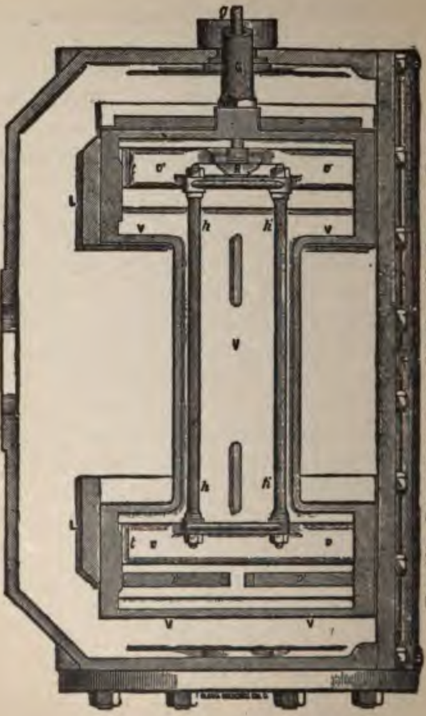


FIG. 101. SECTION ON LINE *CC*, FIG. 103, BUCKEYE ENGINE.

a combination of both adjustments as will leave the speed the same as before. This will be accomplished by diminishing the leverage about twice as much as the tension is increased.

Q. Suppose that the governor shows a disposition to race, or is too slow in settling to equilibrium, what may be done?

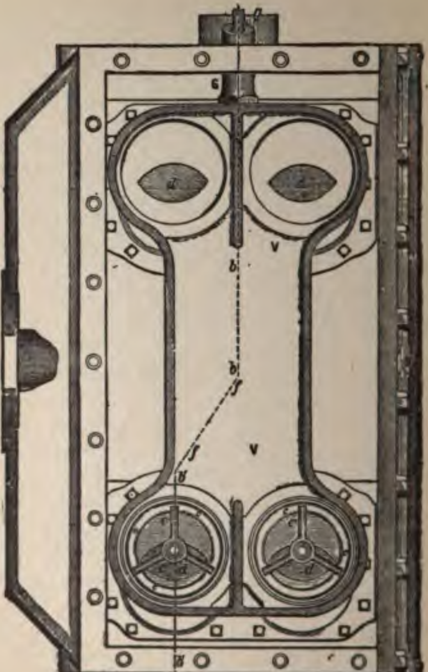
A. The tension may be diminished or the leverage increased, or both together in the proportions just named, if it be desired to avoid the necessity of changing the weights to correct speed.

Q. What preacution should be observed in changing leverage?

A. Not to increase it so much as to cause the links and springs to interfere at mid-movement, and not to diminish it so much as to reduce the power required to operate the valve without undue disturbance of the equilibrium.

Q. What does this first precaution require?

A. That the eccentric be pulled ahead far enough to see if the links and springs clear each other. In high speed engines a slight



interference will not matter as centrifugal force will bow the spring outward, if not restrained, sufficiently to clear.

Q. If it be desired to change speed how can you cipher out the required change of weight of the governor?

A. Multiply the square of the existing speed in turns per minute by the existing effective weight and divide the product by the square of the desired speed. The quotient will be the desired effective weight.

Q. How is the effective weight tested?

A. By putting a three-cornered file on a platform scale and having removed a lever from the wheel, letting it rest on the file at a point about two thirds its length from the pivot, or about where the centre of the stop comes when the lever rests upon it, while the pivot end rests on an independent support directly under the centre of the pivot hole (or it may be suspended by a string tied in the pivot hole). Add to the weight thus found about one third to one half the whole weight of the link which connects the lever to the eccentric.

Q. How can you take out the valve of the Buckeye engine?

A. Disconnect the cut-off stem at the ball and socket joint and draw it out far enough to be well out of the way of the main valve when its stem is unscrewed. Disconnect the rod connecting the main stem with the rocker and unscrew the stem. (Do not loosen the clamp wrist until the stem has been started, because it may be necessary to use the wrench upon this as well as upon the hexagon of the stem.) Slack up the cover plates of the equilibrium rings, to relieve the valve of the pressure of the springs and also to avoid the danger of the rings being thrown into the chest. (If the stem cannot be revolved without unclamping the attached rest, its position on the stem should be marked before loosening it.)

Q. What is the remedy for slamming valves?

A. To deepen and widen the grooves across the valve face just back of the port.

Q. Is there any way which will stop slamming by causing a greater evil?

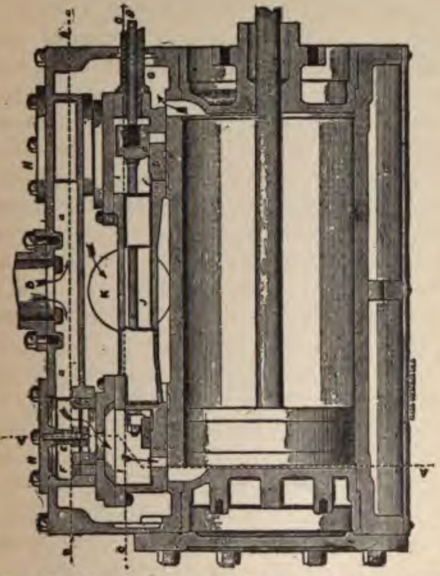


FIG. 103. SECTION THROUGH CYLINDER AXIS, AND ON LINE b_1b_1 ff, $b'b'$, FIG. 102, THROUGH VALVE AND PISTON, BUCKEYE ENGINE.

A. Yes; plugging the steam holes in the valve face; but while this will stop slamming, it will cause greater friction and poorer lubrication of the neighboring surface.

Q. What are the indications of a loose stem?

A. Vibrations to and fro at each stroke: and if very loose, more or less thumping when the motion is reversed.

Q. How can the main stem stuffing-box be adjusted while running?

A. By slacking the holding nuts and pushing the box inwards and holding it with moderate force while the nuts are being retightened.

Q. What are the causes of clicking valves?

A. (1) The inclined supports may not fit the feet of the valve proper at their outer or higher margins; (2) the two plates forming the valve may be out of alignment; or (3) the stem when screwed home may not be in perfect alignment with the valve.

Q. What should be done if the inclined supports do not fit the feet of the valve at their outer and higher margins?

A. The lower and inner parts of the inclined supports should be scraped or filed away, or the feet dressed off.

Q. What should be done if the two plates forming the valve are not in perfect alignment?

A. Take off the cover plates of the equilibrium rings, and with a hammer handle tap on the valve to locate those parts which are not in contact with the seats. Then take a long chisel and cut into the collars of the stretched rods at the points in question so as to turn them in a contrary direction to that in which tightening the nuts tends to turn them.

Q. If the valve clicks by reason of the stem being out of line with the valve, what should be done?

A. Slack the connection.

Q. What should be done when the balance-ring orifices get imperfect from corrosion or wear?

A. They should be rebored and new rings fitted to them.

Q. Suppose when so refitted there should

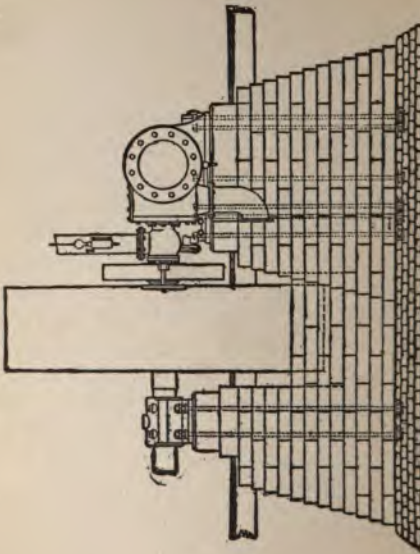


FIG. 104. FRONT ELEVATION, TANGYE PATTERN, BUCKEYE ENGINE.

be too much pressure upon the valve, what should be done?

A. More holes should be drilled, or little cavities may be chipped around those already in.

Q. What is the effective leverage of the springs?

A. The shortest distance from a line passing through the axis of a spring to the lever pivot.

Q. When the spring is bowed out by centrifugal force, from what line is effective leverage measured?

A. From a line tangent to the curved axis of the spring at its point of attachment.

Q. Will this bowing increase or lessen the power of the spring?

A. Lessen it.

Q. How may it be prevented?

A. The spring may be prevented from curving by friction rollers, as is frequently done latterly with high speed.

Q. How do you increase the speed of a Buckeye engine?

A. By one or more of the following changes:

(*A*) Diminishing the amount of weight on the levers.

(*B*) Moving the weights along the levers towards the pivots.

(*C*) Moving the spring clips along the levers from the pivots.

(*D*) Using stronger springs.

(*E*) Increasing the spring tension.

Q. Are all these methods equally desirable? If not, state how far each may be carried.

A. Change (*A*) is preferable when the levers have heavy or medium weights on them, but should not be carried to the extent of removing all or most of the weight, as the centre of force of the levers themselves and their connecting links is nearer the centre of motion than when the levers are weighted; consequently, if before the change the tension of the springs was up to the limit, racing will be induced by removal of the weights, and the reduction of tension required to stop it will counteract the desired effect of reduction of weight.

Change (*B*) should not be carried to the extent of moving the weights off the inner bumpers.

Change (*C*) should not be carried to the extent of causing the link heads to strike the springs, as tested by turning the eccentric ahead by means of its balance weight. A slight interference would not, however, be objectionable, as the centrifugal force of the springs will cause them to clear when running.

Change (*D*) is always preferable for considerable changes, as the governor works best with ample weights on levers.

Change (*E*) is always admissible to whatever extent it can be applied without loss of stability of equilibrium, that being the limit of increase of tension for any purpose. When change (*C*) is made, about one half as much tension may be added as the clips have been moved, without fear of racing.

Q. How would you make cut-off earlier at both ends of the Buckeye engine ?

A. With the engine under consideration the cut-off is under control of the governor by which it is automatically made earlier

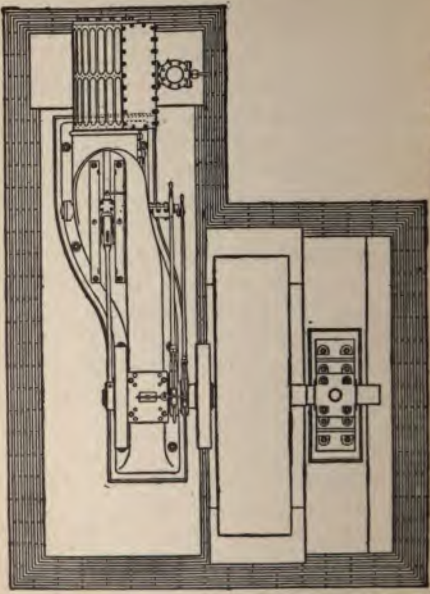


FIG. 105. PLAN VIEW, TANGYE STYLE, BUCKEYE ENGINE.

or later as required by changes of load and pressure. But the earliest cut-off within the range of adjustment may be made earlier by advancing the governor wheel on the shaft.

Q. How do you make cut-off earlier at crank end only?

A. With the qualifications just stated, by advancing the wheel as before called for, and at the same time shortening the connection between the cut-off rocker arm and the cut-off stem sufficiently to leave the cut-off at the other end same as before.

Q. How do you make the exhaust release earlier at both ends?

A. (*A*) Without change of laps; by advancing eccentric: but this will also make all the other functions of the valve (admission, compression, etc.) earlier.

(*B*) By cutting off the ends of the valve (diminishing exhaust lap), which will leave admission undisturbed, but will make exhaust closure later.

(*C*) By cutting off exhaust lap as in case (*B*) and at the same time advancing eccen-

tric sufficiently, the exhaust closure may be left as before.

(*D*) By making changes (*C*) and also adding steam lap, all functions except cut-off and maximum port opening may be left about as before, and as the cut-off of the main valve is always preceded by that of the cut-off valve, the former is of no consequence.

Q. How would you make exhaust release earlier at crank end only ?

A. (*A*) Without changing laps; by advancing eccentric and at the same time shifting valve from crank end sufficiently to leave exhaust release at other end same as before; but this would be accompanied by earlier admission and later cut-off at crank end, and later admission and earlier cut-off at other end.

(*B*) By cutting off exhaust lap at crank end; but this would cause later compression (cushion) at the same end, this feature being unavoidable.

(*C*) By changes (*A*) together with sufficient steam lap added at crank end to restore equality of admission or sufficient in-

crease of steam lap at both ends (most at crank end) to equalize admissions at same time in crank movement as before. But this would cause an earlier cut-off and reduced port opening.

(The port opening can in all cases be maintained against increased steam lap, by increased valve travel, but the problem of tracing out all involved changes and the adjustments required to correct them becomes too complex for treatment in limited space.)

Q. How do you make cushion earlier at both ends?

A. (*A*) Without changing laps; by advancing eccentric: but this causes corresponding acceleration of all other function.

(*B*) By advancing eccentric and at same time adding sufficient exhaust lap (making valve longer) to keep exhaust release as before: but this would cause an earlier admission and cut-off.

(*C*) By changes (*B*) together with sufficient added steam lap to keep admissions as late as before; but this would bring about earlier cut-off and reduced port opening.

Q. How would you effect earlier cushion at crank end only?

A. (*A*) Without changing laps; by advancing eccentric and at same time shifting valve towards crank end sufficiently to leave cushion at other end same as before: but this would cause an earlier admission and cut-off.

(*B*) By adding exhaust lap at crank end (making valve longer at that end), but at the expense of later exhaust release at same end.

(*C*) By advancing eccentric and at same time cutting off exhaust lap at other end sufficiently to leave compression at that end same as before; but these would bring about earlier exhaust release at both ends (more exhaust acceleration at the end cut than at the other), earlier admission, and earlier cut-off.

(*D*) By changes (*C*) with at same time sufficient addition of steam laps to leave admission as before; but this would cause earlier exhaust [as per (*C*)], diminished opening, and more cut-off acceleration than as per changes (*C*).

Q. How would you increase the lead of a Buckeye engine at both ends?

A. (*A*) By advancing eccentric, but at the expense of acceleration of all other events.

(*B*) By reducing steam lap, but at the expense of later cut-off and greater opening.

(*C*) By changes (*A*) and (*B*) in proper proportion to give desired lead and increase without undue acceleration of any other event.

Q. How would you increase the lead at crank end only?

A. Preferably (*A*) by diminishing steam lap at that end, as that makes cut-off later, and other things being equal the cut-off will be earliest at that end, owing to the virtual shortening of the connecting rod when deflected, and the consequent displacement of the proper position of the piston towards the crank, more or less, at all points except the dead centres.

(*B*) By shifting valve towards the crank end, and advancing eccentric sufficiently to leave same as before at other end, but at the expense of inequality in all other events.

ADJUSTING CORLISS ENGINES.*

Q. In engines of this type (having a detachable valve gear, where the motion for working the valves is derived from the action of an eccentric) where there is no lap of the valve to be worked off, or the steam valve set edge to edge with the port opening, where would the eccentric be when the crank was on either centre?

A. At half throw.

Q. Then where, during the rotation of the shaft, would the eccentric arrive at its greatest throw, and the opening motion of the steam valve cease, and thus the detaching mechanism remain inoperative?

A. About where the crank was on either dead centre.

Q. Then when, if at all, must any liberation of the cut-off gear, actuated by the governor or other means, take place?

A. Before this point is reached in the crank travel, or before the eccentric commences its return stroke.

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* See also under "Fraser & Chalmers Corliss" and "Harris Corliss."

Q. If this action has not taken place, what then happens?

A. The steam valve commences to close positively at a speed governed by that of the eccentric.

Q. In order to have a safe working lap of the steam valve, before the exhaust port upon that end is opened to atmospheric pressure, or to the condenser, and thus prevent any blowing through during the relative time of closing the steam and opening the exhaust valves, what is essential?

A. That each valve admitting steam to the engine should be given a definite advance in its movement relative to that of the exhaust.

Q. What is this commonly called?

A. Lead, or steam lead.

Q. Which require the most proportionately—large or small engines?

A. Large.

Q. What effect has it upon the period of expansion?

A. It decreases it, by allowing less time during the travel of the eccentric before it reaches its full throw for the cut-off to act.

Q. Where must this occur in this case?

A. Before half stroke is reached, or upon the opening motion of the steam valve.

Q. When we see a card from a Corliss engine showing cut-off after half stroke, what does it indicate?

A. That the piston (which is at its maximum velocity at half stroke) has had time to travel a little before the valve gear had been actuated so as to fully cover the port.

Q. Where is this apparent cut-off, taking place after half-stroke has been reached, more prominently defined on the card?

A. As we increase the lap of the steam valve.

Q. By increasing this lap, what are we enabled to do?

A. To open the exhaust valve sooner for the return stroke, thus giving a free opening for the exhaust in relation to the former, and necessarily enforcing a later closing of the valve, reducing the amount of compression.

Q. What are the amounts of steam-valve lap and exhaust-valve opening for various sizes of Corliss engines?

A. They are given in the following table.

POSITION OF STEAM AND EXHAUST VALVES WITH WRIST LEVER AT ITS CENTRE OF MOTION.

SIZE OF ENGINE.	LAPS OF STEAM VALVE.	EXHAUST VALVE OPEN.
12″	$\frac{1}{4}$″	$\frac{1}{32}$″
14″	$\frac{5}{16}$″	$\frac{1}{32}$″
16″	$\frac{5}{16}$″	$\frac{1}{32}$″
18″	$\frac{3}{8}$″	$\frac{1}{16}$″
20″	$\frac{3}{8}$″	$\frac{1}{16}$″
22″	$\frac{3}{8}$″	$\frac{1}{16}$″
24″	$\frac{7}{16}$″	$\frac{3}{32}$″
26″	$\frac{7}{16}$″	$\frac{3}{32}$″
28″	$\frac{7}{16}$″	$\frac{3}{32}$″
30″	$\frac{1}{2}$″	$\frac{1}{8}$″
32″	$\frac{1}{2}$″	$\frac{1}{8}$″
34″	$\frac{1}{2}$″	$\frac{1}{8}$″
36″	$\frac{1}{2}$″	$\frac{1}{8}$″
38″	$\frac{9}{16}$″	$\frac{3}{16}$″
40″	$\frac{9}{16}$″	$\frac{3}{16}$″
42″	$\frac{9}{16}$″	$\frac{3}{16}$″

Q. How is this amount for each end of the cylinder obtained?

A. By lengthening or shortening of the connection leading from wrist lever to exhaust arm, *while the* wrist lever still re-

mains at its centre of motion, until we bring the marks on the end of the exhaust valve to the distance required from the closing edge of the exhaust port.

Q. If we shorten one steam connection, what is the effect?

A. To allow that end to open quicker than its neighbor, but at the expense of a reduction in the safe working lap that it should have with relation to the exhaust valve.

Q. If we lengthen the connection what do we do?

A. We increase the lap of the valve, with the effect of opening it later, which condition would call for a greater advance of the eccentric with relation to the crank.

Q. In the wrist plate there are usually three marks; what do they indicate?

A. One represents the position at half travel, or centre of motion; one the wrist-plate position at out-board stroke end; and the other its position at in-board stroke end: these three coinciding at the points named, with a mark on the wrist-plate stand or pin.

Q. What marks indicate the location and width of port openings?

A. There is a mark on each face of the valve port (shown when the back bonnets are removed) which comes in line with a mark on the opening edge of the valve.

Q. In preparing to set valves, what is the first operation?

A. To place the wrist lever at half throw, which, for horizontal engines, is represented by the centre of carrier and wrist-lever pin being plumb. At this position, designated above, the marks on the wrist lever and pin should correspond, and the whole mechanism be secured in that position by placing pieces of paper between the washer on the end of the pin and wrist lever, so as to produce friction sufficient to hold the whole in the desired position when the nut on the end of the pin is screwed up. This being accomplished, we may consult the annexed table giving the lap of the steam valve, and the relative position of exhaust valve when the wrist lever is at its centre of motion; and thus fix upon the lap for the steam valve and the position of exhaust

valve desirable for the size of engine under consideration. By a lengthening or shortening the connections leading from this wrist lever to steam lever we bring the position of the opening edge of the steam valve to correspond with the amount of lap fixed for that case, which, of course, should be the same for each end of the cylinder. For the position of the exhaust valve, by consulting the table on page 211, we find for a 20" engine $\frac{1}{16}$th of an inch opening.

Q. If we lengthen the connection leading to exhaust arm, what do we do?

A. We add lap to the valve, and increase the amount of compression at one part of its movement, and for the other part make its time of opening later, relative to the movement of the piston. We also retard the exhaust to the condenser.

Q. If we shorten the connection, what do we do?

A. We increase the opening when the stud-plate is on its centre of motion, and consequently decrease the amount of compression thereby, with a corresponding earlier opening of the exhaust port.

Q. What does this additional opening given to the valve by shortening connections also do?

A. It reduces the lap of the valve over the part that the exhaust valve should have during the period of time coincident with that of the steam valve when upon the point of opening for the admission of steam to the cylinder.

Q. After we have "squared the valves," to use a shop phrase, what is necessary?

A. Look after the carrier and eccentric rods, and see that their travel is equidistant from an established centre line of motion.

Q. To what must we give our attention first?

A. To the rod leading from eccentric to carrier arm, and termed the eccentric rod. (This rod is the first acted upon, and after once adjusted, will not be affected by any future adjustment found necessary for the carrier, or rod leading from carrier arm to wrist lever.)

Q. Under what circumstances might this be found necessary?

A. If we should reverse the operation,

and thus make it necessary to go over the work a second time.

Q. After we have found that the throw of the carrier lever is equidistant from an established plumb line, in its extreme travel each way, brought about by adjustments in the length of the stub end, in the end of the eccentric rod, until such a result is accomplished, what may we do?

A. We may repeat the operation of turning the engine by hand for the benefit of the carrier rod, or the connection leading from the wrist lever to the carrier arm, and so adjust its length that the wrist lever will travel the same amount each way from the centre of motion fixed by the marks upon the wrist lever and pin.

Q. As we now have the valves adjusted relatively to one another, and also the throw of the carrier arm and wrist lever equally divided from centre of motion, what do we do next?

A. Place the crank upon one centre or the other, and roll the eccentric around on the shaft in the direction that the engine is to run, until we bring the opening edge of the

steam valve on that end of the engine that is next to take steam, $\frac{1}{32}$d of an inch beyond the line on the valve face representing the opening edge of the port, and secure the eccentric in position.

Q. What is well then ?

A. To bar the engine around to the other centre, and note if a similar opening is obtained, which will be the case if the rods are properly adjusted.

Q. After satisfying ourselves of the correctness of the movements, what may we do ?

A. Replace the back bonnets, and proceed to adjust the cam rods leading from the governor to the detaching levers on the valve gear.

Q. In adjusting these cam rods what should we first do ?

A. Block the regulator up to its extreme point of travel, and secure it, for a time, in that position. Then lengthen or shorten the rods leading from the governor to the valve gear on each end of the cylinder so as to bring the detaching apparatus into action, and allow the valve to be unhooked, with

the regulator in that position, when we roll the valve around by means of a starting bar placed in the wrist-lever, until the steam port is uncovered about $\frac{1}{8}$th of an inch.

Q. What is the object of this adjustment?

A. To prevent the engine getting beyond the control of the governor, if the load is suddenly removed from it by breaking a shaft or belt in the mill, or by extreme variation of the load, as in rolling-mill practice, and similar service.

Q. After the adjustment of cam rods has been made, what is next proper to do?

A. To lower the governor down to its lowest position, to see that the valve gear will not be detached at that level.

Q. In this position of the governor how far should steam follow?

A. Full stroke.

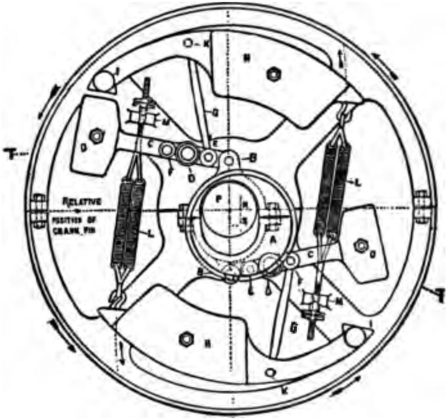
Q. In this position when should the valves be liberated?

A. Not until the governor has reached an elevation corresponding to nearly the normal speed of the engine and the load carried.

ADJUSTING THE FITCHBURG ENGINE.

Q. How is the adjusting of the Fitchburg piston valves effected ?

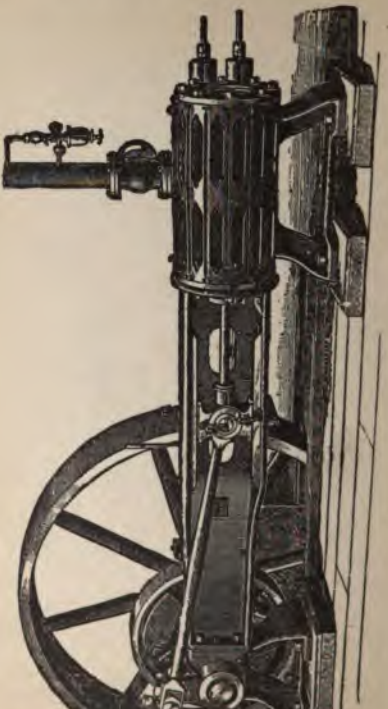
A. By loosening the bolts of the clamps and sliding the rods through the clamps



FITCHBURG GOVERNOR.

either way, as desired, and then re-tightening the bolts in the clamps.

Q. How would you increase the speed of a "Fitchburg" engine ?



FITCHBURG GIRDER FRAME ENGINE.

A. Either by tightening equally the tension on both sets of springs in the governor, or by decreasing the weight of the centrifugal weights.

Q. How do you make maximum or latest possible cut-off earlier at both ends?

A. The governor completely controls the point of cut-off, but has no effect on exhaust release or on "cushion." A decrease of the throw of the eccentric in the cut-off governor would have to be made, but never needed, as three-fourth cut-off is early enough for any automatic engine to adopt as its latest.

Q. How do you make cut-off earlier at crank end only?

A. The valve rod is attached to its operating mechanism by sleeve clamps, by which the valve can be adjusted for relative time of closure.

Q. How do you make exhaust release earlier at both ends?

A. By advancing exhaust eccentric (which would also increase the "cushion" unless the heads of exhaust valves were separated by placing washers between the valves and

FIG. 106. FRASER & CHALMERS-CORLISS ENGINE.

rods, dash pot, and disc plate of a Fraser & Chalmers-Corliss engine put in place?

A. The valves are all well marked to their respective places in the cylinder. All the valve connecting rods are screwed up tight to proper length (after adjustment

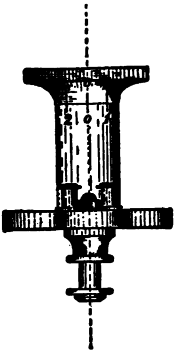


FIG. 107.—WRIST PLATE.

and setting of valves in shop) before shipment. The dash pot connecting rods require adjustment after dash pots are in place. (In the present style of engines the position of dash pot is unalterably fixed by a finished seat for each in the feet of cylin-

der.) Move the disc plate (see Fig. 107) until line *I* marked on same meets line *0* marked on fixed disc bracket, then adjust the dash pot so that the claw of the valve connecting rod to steam valve engages the blow block free and easy; repeat this with the other steam valve connecting rod.

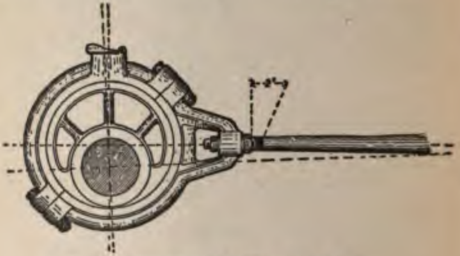


FIG. 108.—ECCENTRIC AND ROD.

Q. What makes the first connecting rod especially easy to adjust?

A. The lines 1 and 2 on the disc plate represent its travel. The first eccentric rod will require no adjustment if placed as in Fig. 108, it being so marked on every engine, and the measurement from nut to mark being always two inches. Secure the eccen-

tric to the shaft as it is marked, always ahead of the crank—whichever way the engine is required to run.

Q. How would you adjust the governor and the cut-off rods?

A. Bolt the governor stand to its place on engine frame, first removing any grit or dirt upon surfaces which come together. Connect the cut-off rods to cut-off cams,

FIG. 109.—GOVERNOR SAFETY COLLAR.

also the governor rods and fixtures. The cut-off rods are already adjusted to proper length before shipment from the shop and screwed up tight. If loosened by accident, they should be set thus: set the governor in the top notch of the collar (see Fig. 109), unhook second eccentric rod from disc plate,

covers where the edges of ports and valves are marked plainly by chiselled lines, and set the valves according to fig. 110. Adjust the length of eccentric rod so that the valve disc swings equal both ways from the centre line on hub of disc (see fig. 107). Place the valve disc in the centre (lines O and O, fig. 107) and set the valves as shown above, the admission or steam valves to have 5-16 inch lap, the exhaust valves edge to edge. Set the crank on the dead centre. Turn the eccentric ahead of the crank pin in the direction the engine is to run until the valve shows 1-16 inch opening, then secure the eccentric. Turn the crank in the same direction around to the other dead centre. If any difference of opening is detected, it can be adjusted by the nuts on the eccentric rod, moving the rod in or out as the case may require.

THE GARDNER ENGINE.

Q. How would you proceed to set up a Gardner * three-cylinder engine, if every piece was separate from the others?

* Eagle Iron Works.

A. (1) Lay the engine down valve side up; put on the chests and valves, connecting valve stems to eccentric blocks; put on the eccentric and set valves. This is all done by the one eccentric at one time; one revolution of the eccentric moving the three valves.

(2) Take the pistons and insert ball end of piston rod into socket in piston and fasten the follower into place. Spring the piston rings into place and insert pistons into cylinders from out ends.

(3) Set the engine upon its foot, and through the back opening insert the short or front shaft which runs governor and valve motion only.

(4) Put in the crank shaft, first putting on bronze pin box and clamp ring, and insert it so that small end of crank pin enters the front shaft-crank disc and clamping ring connects the piston-rods. Push the pistons into cylinders until the crank ends are close enough together to put on the outside clamp ring.

(5) Wipe out cylinders clean from grit and oil; then put on cylinder heads; then

fasten engine to bed-plate and put on steam pipe in front or valve side ; set governor in place on top of steam pipe ; then put on back bearing, sliding it on the shaft, bolting it into place. Put on pedestal and caps. Connect steam and exhaust pipes. Put lubricator on to steam pipe. Put on and key fly-wheel.

Before starting, open cylinder cocks and warm up engine. After starting, leave cylinder cocks open until cylinders are free from water ; then close them.

Q. What can you say in regard to the governor?

A. In putting governor together place the valves on so that the set screws will be on opposite sides from shaft, and see that the joint of cover is made on with a thin coating of red and white lead, well mixed with boiled oil.

Q. How would you change speed?

A. Remove plug in case and turn engine over until a slotted screw is seen upon the inside. To increase speed, turn screw outward; to lessen, inward. There are two of these slotted screws, one on each valve; both can be used if necessary.

THE HARRIS-CORLISS.*

Q. Where will the marks showing about the valve adjustment of a Harris-Corliss engine be found?

A. Upon the back bonnet side of the cylinder, and upon the back ends of the valves.

Q. What marks will be found?

A. For the steam ports there is a mark upon the cylinder coinciding with that edge of the port which is towards the end of the cylinder; and a mark upon the back end of the valve coinciding with the edge of the valve towards the end of the cylinder.

Q. In the Harris-Corliss engine, in which direction is the lap movement of the steam valve?

A. Towards that end of the cylinder in which the valve is placed.

Q. In this type of engine, which is the opening edge of the exhaust valve?

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* It will be well in this connection to read under the head of "Corliss Engines" page 208: also to note resemblances and differences under head "Fraser & Chalmers Corliss."

A. That side of the opening towards the centre line of the cylinder. It is marked upon its back end.

Q. What marks has the wrist plate ?

A. Marks showing the extremes of travel of its centre of motion.

Q. How do you set the valves of a Harris-Corliss engine ?

A. Put the wrist plate upon its centre mark ; then by the adjusting threads set the exhaust valves at the point of opening ; then lap the steam valves to the desired amount (from $\frac{1}{8}$ to $\frac{3}{4}$ inch ; large engines requiring the most lap have lead), then connect the wrist plate and the eccentric by the eccentric rod and hook ; turn the eccentric upon the shaft to see if the wrist plate takes its full travel. Adjust the eccentric rod socket screw until the plate gets just the right travel. Put the crank upon either dead centre ; roll the eccentric enough more than $\frac{1}{4}$ revolution ahead of the crank, to show the opening of the steam valve nearest the piston, of $\frac{1}{32}$ to $\frac{1}{8}$ inch lead, according to the speed : the highest speeds taking the most lead. Tighten the eccentric set

screw, and turn the engine over to see if the other steam valve is set relatively the same. If it is not, adjust by shortening or lengthening its connections until it does.

Q. When this make of engine is at a state of rest, in what position is the governor

A. The weight of the balls rests upon a pin in the side of the governor column.

Q. How can the cam rods be adjusted ?

A. Let the governor balls rest upon the stop motion pin. Move the wrist plate to one end of its travel, and adjust the cam rods for the steam valve which is now wide open, to bring the steel cam on the cam collar in contact with the circular limb of the cut-off hook ; move the wrist plate to the other extreme of travel, and adjust the other cam rod in the same manner.

Q. How do you test the correctness of the cut off of the Harris-Corliss engine ?

A. Back up the governor to about its medium height. With the eccentric connected to the wrist plate, turn the engine shaft slowly in a go-ahead direction, and when the cut-off hook is detached by the cam, stop and *measure* upon the guide the

distance that the cross head has travelled; then keep on turning the shaft, and see that the other steam valve is tripped when the cross head has made the same distance. If the cut off is not equal, adjust the cut-off rods until they become so.

ADJUSTING THE IDE ENGINE.

Q. How do you increase the speed of an Ide automatic cut-off engine, with valve on the side?

A. By moving the weights nearer to the fulcrum of the governor levers, or by increasing the tension on springs.

Q. How do you make the governor regulate more closely?

A. By moving the sliding block to which the end of the spring is attached nearer to the rim of the wheel.

Q. How do you make cut-off earlier at both ends?

A. The cut-off is determined by the position of eccentric, which is determined by the speed, and the load will regulate the

speed, and a slight change of speed takes place in running the engine light or loaded.

Q. How do you make exhaust release earlier at both ends?

FIG. 111. OLD IDE GOVERNOR.

A. The exhaust release is fixed and can be made earlier only by shortening the valve.

Q. How do you make exhaust release earlier at crank end only?

A. By lengthening the valve rod, or shortening valve at crank end.

Q. How do you make cushion earlier at both ends?

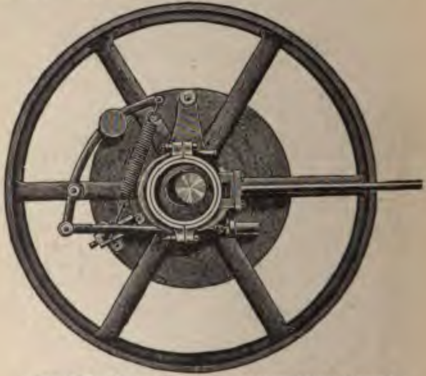


FIG. 121. IDE GOVERNOR (Simplified Form).

A. This can only be accomplished by making a longer valve.

Q. How do you make cushion earlier at crank end only?

A. By shortening the valve stem.

Q. How do you increase the lead at both ends?

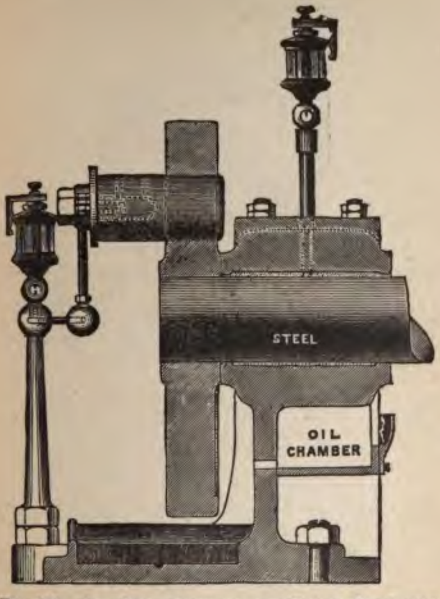
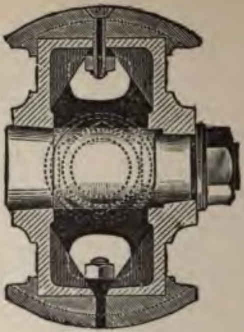
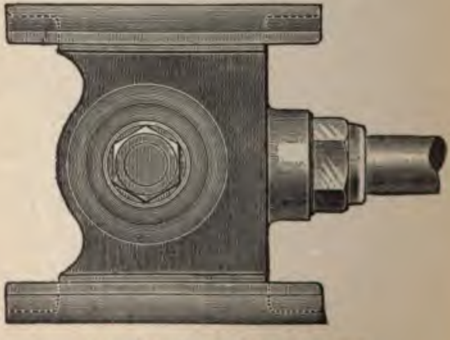


FIG. 113. IDE MAIN JOURNAL AND CRANK PIN LUBRICATING DEVICES.





FIGS. 114 AND 115. IDE CROSSHEAD.

A. The position of eccentric on the shaft is fixed and the lead on either or both ends can be changed by making an off-set in the key which secures the wheel and eccentric to the shaft; or by cutting off the inside edge of the valve.

THE NEW ECONOMIZER ENGINE.

Q. In starting a "New Economizer" portable engine what should you do?

A. See that the cylinder-cocks are open at the cylinder, and always open first before stopping, and leave them open until starting again; then open the starting valve slowly at first, until the engine is up to its speed; and when the water is all out of the cylinder, close the cocks.

Q. Should the pump fail to work what should you do?

A. Close the stop cock at the boiler where the check-valve is, and unscrew the cap over the check valve; take out the valve, and clean the seat and the valve of any dirt, and replace them again, after which open the stop cock again at the boiler.

If the pump still fails to work remove the air chamber, which is over the valves of the pump; remove the valves and clean them of any dirt there may be on the valve or in the chamber, and replace again, and the pump is in working order. See that suction pipe or hose is properly put on, so that it does not leak air, which sometimes causes failure of pump to work.

Q. How would you pack the piston rod, valve rod, and pump plunger?

A. By unscrewing the caps on the stuffing boxes, and with a hooked wire pulling out the old packing; then, filling the stuffing boxes with good hemp packing, braided or twisted up into a kind of cord, size of the space around the rod, oiling well before putting it in, being careful not to draw them up too tight; rather having them a little loose, so a little water will leak through; this will keep the packing moist and in good order, and not cut up the rods, which happens when the packing is drawn up very tight.

Q. How would you regulate the speed of the engine?

A. The governor is provided with a speeder, by which the speed can be varied to suit circumstances. The arrangement is a spring on the side of the governor, which, by tightening, will increase the speed, and by loosening. will decrease the speed. By this arrangement the speed may be regulated while the engine is in operation.

Q. How would you change the point of cut-off, or reverse the engine?

A. Loosen the nuts that hold the eccentric ring to the eccentric plate and push the ring slightly toward the shaft to cut off closer; farther from the centre if desired not to cut so close. Pushing the ring in the slot so that it passes the centre, and the body of the ring is on the opposite side of shaft, reverses the engine.

Q. How would you adjust the engine?

A. The crank-shaft boxes and the eccentric straps are provided with thin liners between them; by reducing them the adjustment is made. But before doing this one should see that the nuts on the bolts of these parts are drawn up tight, and if they are, and an adjustment is required, should

reduce but little at a time. This is the safest way of adjusting, and is very simple. To reduce the liner, the nuts and caps should be taken off and removed, replaced again, and drawn up tightly.

SETTING UP THE PHŒNIX ENGINE.

Q. How would you proceed to set and start a Phœnix engine?

A. After setting, accurately leveling and firmly securing to the foundation the bed plate and outboard bearing, take the crank shaft and slip over it the governor with its accompanying eccentric pushing it well up the exhaust eccentric which is already in place upon the shaft; taking care to keep the open side of the governor away from the exhaust eccentric. Next insert the shaft in the fly wheel (and pulley if any) and lower the whole to its place in the bearings. Remove the pin from the cross head, slip the connecting rod over the crank pin and bring it back until it enters the cross head, first placing the steel bushing in the connecting-rod brasses, with the large end

FIG. 116. PHŒNIX ENGINE.

of the hole outward ; insert the cross-head pin and drive it to its shoulder with a hard-wood block and secure it by means of the nut on the back of the cross head. (Place the engine on its forward centre while doing this, as that brings the nut within easy reach of the bent wrench provided for the purpose.) Then tighten up the nut on the outer end of the cross-head pin.

Set up the post which carries the sight feed oil cup for the crank pin, the covering plate and washer, which carries the centrifugal oiler, slipping the ball over the end of the tube leading from the post, and placing the ball exactly in the centre of rotation, taking care that there is no contact between moving surfaces. To arrange the oiler for the cross-head pin, screw the little tube with the elbow into the hole in the crosshead above the pin and screw the brass cup with brush into the elbow ; place the little column with cross bar in the tapped tube, on top of the bed plate, nearest the crank shaft and adjust the tube leading down from the sight feed cup so as just to clear the top of the brush.

Screw the large column and cross bar with two tapped holes in place on the main bearing cup, and insert the two oil cups for eccentrics.

Put on the eccentric straps and rods and see that none of the liners between the cones on the various pins of the rock arm and belt crank are omitted; also that the centre punch marks on the eccentric rods are the proper distance from the faces of the strap bosses. Draw all the nuts on the rock-arm and bell-crank pins securely to their places, trying each bearing to see that there is perfect freedom of motion. Move the governor around the shaft, in the direction in which the engine is to move, until the mark on the hub is $\frac{2}{16}$ inch ahead of that on the shaft. This gives the engine the proper bend. Screw the governor to its place by screwing up the large set screw through the hub near the arms and the two set screws through the band or collar on the end of the hub. Move the fly-wheel (and pulley if any) to place, and drive the keys in firmly.

Examine the cylinder oiler to see that it

works properly, also the set screws in the governor weights, that there may be no danger of the weights flying off.

After connecting up the steam pipe, take off the back steam-chest cover and remove the valve ; turn on the steam and thoroughly blow out any foreign substance there may be in the pipe ; replace the valve, drive the taper pin through the ball-joint socket and the valve stem, and replace the steam-chest cover. Throw out the eccentric hooks and place the engine on one of its centres. Throw the valve so that the exhaust and steam passages of one end are open at the same time ; turn on the steam and let all water escape and the steam pass through for a little while until the chest is thoroughly warmed.

Insert the starting bar with the lugs away from the engine, turn on a little steam and see that the valve moves freely in the chest ; shut off the steam, reverse the starting bar so as to lock the rock arm and bell crank together ; move the valve until the exhaust eccentric hook can be thrown in ; lock the hook ; reverse the starting bar again and

start the engine by hand slowly; throw in the cut-off eccentric hook and remove the starting bar; care being taken that the eccentric-hook lock nuts are securely fastened. Turn on full steam gradually and the engine is in running order.

SETTING UP AND ADJUSTING A PORTER-ALLEN ENGINE.

Q. How is the bed of a Porter-Allen engine lined?

A. In the usual manner by a line through the cylinder, which is bolted to the end of the bed, in line with the guides.

Q. Suppose the cylinder is not yet bolted on?

A. It is represented by the bore in the head of the bed, and the line is to be contained midway between the side rails of the lower guide bars.

Q. How can the shaft be squared?

A. The crank disc is finished on the shaft centre after the pin has been set, and consequently the face of the rim is at right angles to the axis of the shaft. Test faces

are planed on bed by which the shaft is set, so that the distance between the disc rim is equal at all the faces referred to.

Q. Should the shaft get out of line how may it be squared?

A. By gauging between the rim of the crank disc and bosses provided on the bed.

Q. How can you line the engine with a shaft placed at a higher or a lower level?

A. Supposing that the other shaft is not in place, but is represented by a tightly-drawn line from two points as far apart as practicable, drop plumb lines nearly but not quite touching this line. Then by these, straighten another line parallel with the first, and at the same level as the centre line of the engine and at right angles with this stretch another, representing this centre line, and extend both each way to permanent walls, on which their termination, when finally located, should be carefully marked, so that at any time they may be reset.

In order to get the latter line exactly at right angles with the former, there are two ways; one of which is as follows:

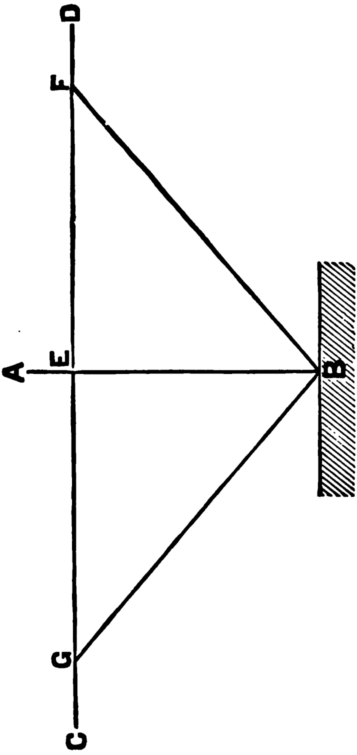


FIG. 117. ENGINE LINING.

One end of a measuring line is attached to some point of the line No. 1, and its other end is taken successively to point on line No. 2 on the opposite sides of the intersection, as shown in Fig. 117, in which *AB* is a portion of line No. 1, and *CD* of line No. 2, the direction of which is to be determined. *BF* and *BG* are the same measuring line fixed at *B* and applied to the line *CD* at successive points *F* and *G*. The distances *BF* and *BG* being the same, when *EF* is equal to *EG*, the lines *AB* and *CD* are at right angles with each other.

By the other method, application is made of the fact that in any right angled triangle the square of the longest side is equal to the sum of the squares on the other two sides; so that if we have a right angled triangle, having the two sides which are at right angles 3 and 4 respectively, the short side, opposite the right angle, will be 5, whether these units are feet or yards; and the same is true of any multiples of these Nos. 3, 4 and 5, as 6, 8 and 10; or 9, 12 and 15.

Q. How can you line the engine with a shaft to which it is to be coupled direct?

A. Supposing that the engine bed and the bearings for the shaft are already about in position, level them by a parallel straight edge and a straight spirit level; then to line them horizontally, run a line through the whole series of bearings, and continue to a permanent wall at each end upon which its endings should be marked. Set a piece of wood in each end of each bearing, and paint or chalk its surfaces white. Find the middle of each piece (by compasses) and draw two fine lines across it equally distant from the middle, and having between them a space a little wider than the thickness of the line. Straining this, nearly touching the blocks (if it is long, separating its sag by them), the two marks on each block must be seen, one on each side of the line, with the line of white between.

Q. When the valves of a Porter Allen engine wear, how may the wear be taken up?

A. By means of the equilibrium plates, which are shown in Figs. 118 to 121 inclu-

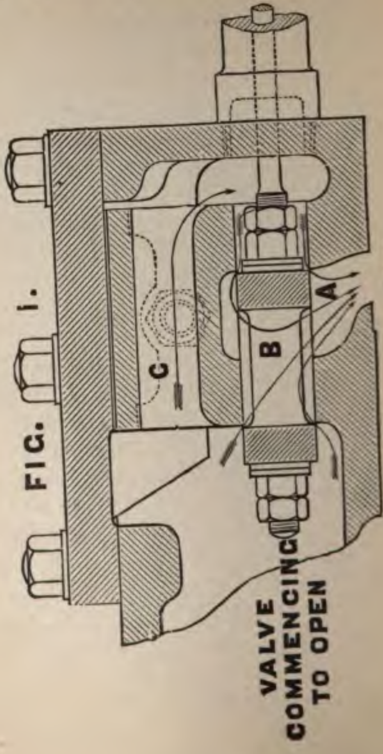


FIG. 118. PORTER-ALLEN VALVE.

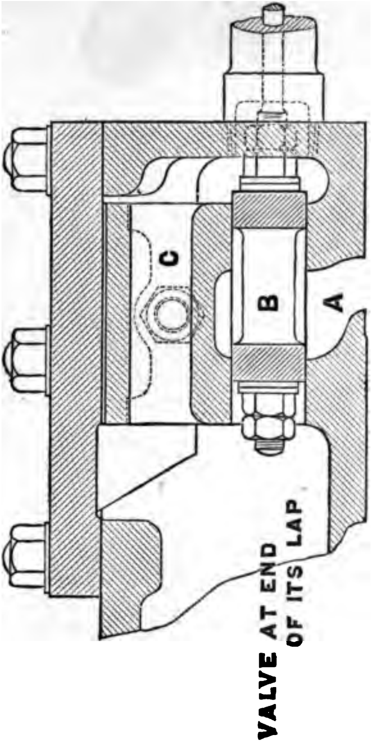


FIG. 119. PORTER-ALLEN VALVE.

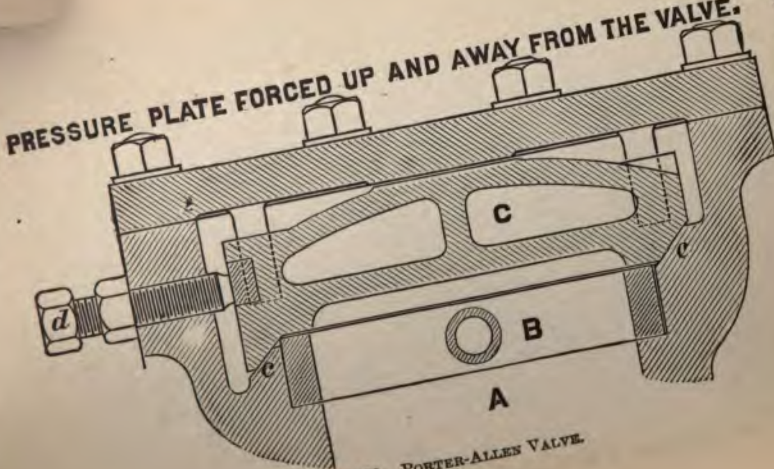


FIG. 120. PORTER-ALLEN VALVE.

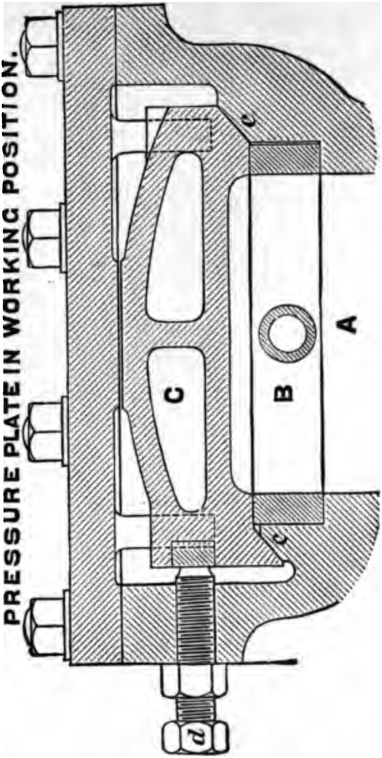


FIG. 121. PORTER-ALLEN VALVE.

sive, which give sections through the steam chest at one end of the cylinder. Figs. 118 and 119 are horizontal sections showing the four opening valves; first, when commencing to open (the arrows indicating the course of the steam), second, at the extreme point of the lap. Figs. 120 and 121 are vertical sections showing the pressure plate; first, when by turning the bolt *d* forward, it is forced up the inclines and away from the valve, leaving a bad leak; and second, when it is let down to its proper working position.

A is the port, *B* the valve, *C* the pressure plate. This plate rests upon two inclined supports *cc*, and the pressure of the steam forces it down those inclines as far as the bolt *d* underneath will allow.

Q. How can you detect leakage?

A. When the engine is warmed up to its working condition, open the indicator cocks, or if there are none, remove the plugs from the top of the cylinder, unhook the link rod, and set the valves by the starting bar so that both ports are uncovered, and turn on steam. If the valve leaks at the end of the cylinder which is not then open to the

air or to the condenser, the steam will blow out there.

Q. Are there any special precautions in making the adjustment of the pressure plate to stop this leak?

A. One person should work the starting bar while another very carefully lets down the pressure plate, observing that the jam nut is tight in place.

Q. How would you do in small engines which have no starting bar?

A. Set the crank at about three-fourths of each stroke, where the steam is sure to be cut off, and fill the valves by moving the governor up and down.

Q. How should a Porter-Allen engine be started?

A. Always with a starting bar, because the valves warm up more quickly than their supports, and will be tight at first.

Q. How would you set the admission valves of a Porter-Allen engine?

A. Place the engine upon its dead centre, as will be seen by the coincidence of the marks upon the collar of the shaft and the corresponding end of the upper box. Then

raise the governor to its highest position, bringing the block between the trunnions of the link. With the governor up, set the valve that is about to open, giving it a lead of $\frac{1}{16}$ to $\frac{3}{16}$ inch, according to the size of the engine.

Q. When after doing this you let the governor down, what will you notice about the valve position?

A. The valve will be moved a short distance towards the crank; thus covering the port nearest the crank and enlarging the port opening furthest from it, so that the lead which is equal at the earliest point of cut-off will be gradually diminished at the crank end of the cylinder, and increased at the back end, as the steam follows further.

Q. Suppose that the indicator shows that the lead of either admission valve requires to be changed, how may it be done?

A. By lengthening or shortening the stem at the socket of its guide bar by means of nuts, bearing in mind that each valve moves towards the middle of the cylinder to open its port.

Q. What care must be taken as regards the setting of the exhaust valves?

A. Before closing the valve chest, to turn the engine slowly through an entire revolution, while the movements of the valves are carefully watched, so as to ensure that they have not been so set as to bring the valves or their nuts into contact with the ends of the chest at the extremes of their movements.

Q. How can you tighten the side boxes of the main bearing of a Porter-Allen engine?

A. By drawing up the wedge with the bolts, by which it is suspended from the cap.

Q. When is the time to do this?

A. When the engine is running, and the freedom of the journal between its side boxes can be felt.

Q. How do you take up the connecting rod boxes?

A. In this engine the crank upon end of the rod is solid, and the boxes are held by a broad wedge which is tapped through; and two bolts are screwed into it, one passing through the upper, and one through

the lower side of the rod. T
boxes, loosen the bolt which e
end of the wedge, draw the w
other bolt, and lock it by t
first one.

Q. How often should the en
cated?

A. About every five hours,
oil in the lubricators to maint
sary head, and putting a few
joints and rockers in the valv

SETTING UP THE PORTER-HAM

Q. How is a Porter-Hamil
up and adjusted?

A. The bed is shipped wit
tached, and at the bottom an
guides are part of the bed-pla
are perfectly symmetrical and
the cylinder. After setting t
a line is stretched parallel an
level with the axis of the cyli
of the engine.

This is easily done witho

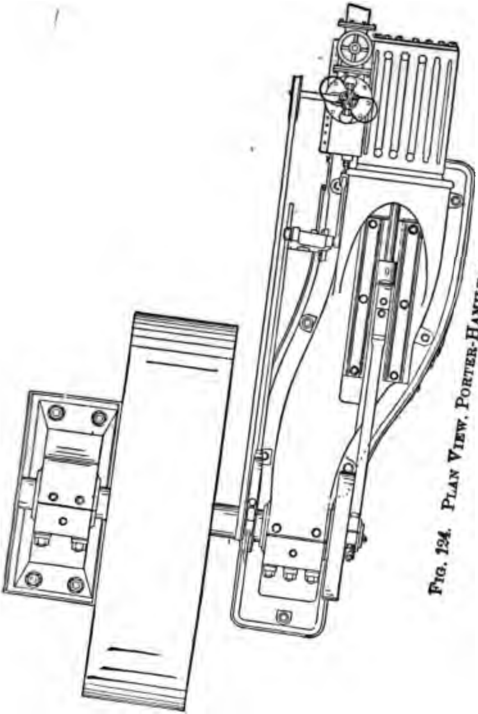


FIG. 124. PLAN VIEW, PORTER-HAMILTON ENGINE.

piston out by setting out equal distances from the centre of the outer end of the cylinder and from the centre of the crank end of the guides. The shaft is then laid in the pillow blocks and levelled up and is squared up by moving the outer pillow block until both sides of the crank disc are equally distant from the line.

The crank disc is turned true after being shrunk on the shaft, and if it is inconvenient to get a level on the shaft it may be levelled by plumbing the face of the disc if it is done carefully. The squaring, leveling and alignment of the line must of course be gone over again carefully before finally setting the outward pillow block.

The bed and pillow block are set in the usual way by pouring melted sulphur under the bed on top of the foundation; care being taken not to allow the sulphur to flow into the bolt holes in the bed around the bolts.*

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* For setting heavy engines the builders prefer filling between the bottom of the bed and the foundation with cement and sand rather than sulphur. Iron borings, sulphur, and sal ammoniac well tamped in makes a very substantial setting for heavy engines.

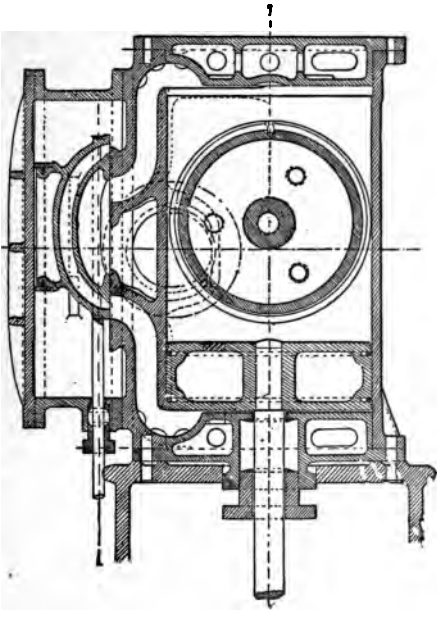


FIG. 125. CENTRAL VERTICAL LENGTHWISE SECTION, PORTER-HAMILTON ENGINE.

Q. If for any reason the valve should not travel square—that is, if the lead should not be equal at both ends, how should it be squared?

A. By screwing the valve stem into or out of the yoke around the valve. Many of these engines are now made with piston valves; and with these the adjustment for squaring the valve is made at the other end of the valve stem when it is screwed into a brass spade handle.

Q. How is the lead changed?

A. By advancing or receding the eccentric.

Q. How would you increase the speed of a Porter-Hamilton engine?

A. The engine having an ordinary throttling governor, small changes are made by the "speeder"; large ones by changing the diameter of the governor pulley. Where the Gardner governor is used, as is ordinarily the case, the speed is increased by sliding out the weight on a horizontal bar.

Q. How would you make cut-off earlier at both ends?

A. By advancing the eccentric.

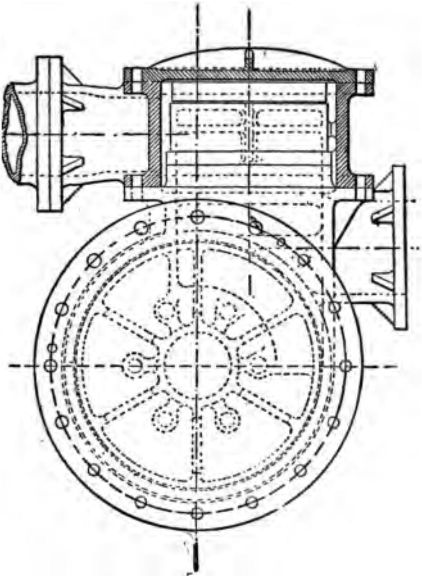


FIG. 126. VERTICAL CROSS SECTION, PORTER-HAMILTON ENGINE.

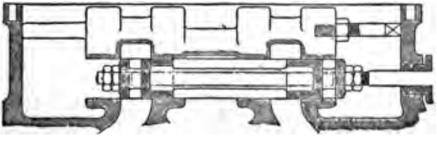


FIG. 127. PORTER-HAMILTON BALANCED VALVE.

Q. Would this affect the admission, exhaust, etc.?

A. Yes.

Q. How would you change the steam lap?

A. The piston heads of the valve are separate and fastened on the valve stem so that the distance between the edges of the valve can be varied. This is the steam lap can be varied but not independently of the exhaust lap.

Q. How would you make cut-off earlier at crank end only?

A. By adding lap to the crank end of the valve.

Q. How would you make exhaust release earlier at both ends?

A. By advancing the eccentric.

Q. How would you make exhaust release earlier at crank end only?

A. By cutting off exhaust lap at that end.

Q. How would you increase the lead at both ends?

A. By advancing the eccentric and cutting off the lap.

Q. How would you increase the lead at the crank end only?

A. By cutting off the lap at the crank end.

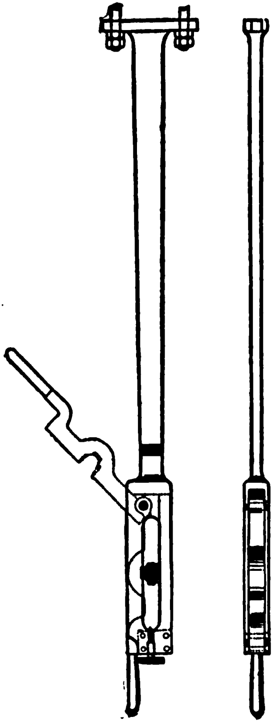


FIG. 128. KIRKEVAAG DROP HOOK.

ADJUSTING THE PUTNAM ENGINE.

Q. How would you go about to attach the regulator of a Putnam engine?

A. After the regulator had been put together, raise the balls to the regulator as high as they will go and hold them in that position; then push in the steam levers far enough to allow the cams which operate them to be turned around, clearing the levers without lifting the valves. While the levers are in this position, tighten the set screw in the rocker arm at the bottom of the regulator, when the balls may be lowered and the regulator attachment made complete.

Q. How would you change the direction of the fly wheel?

A. Before setting the valves, the set screw in the bevel gear on the side shaft (which operates the valve gear) should be screwed up tightly and also the main shaft gear as shown in Fig. 131. The gear *C*, as shown in Fig. 132 on the side shaft, is in the proper position to run the top of the

fly wheel in the direction from the cylinder. To change that direction of motion, the

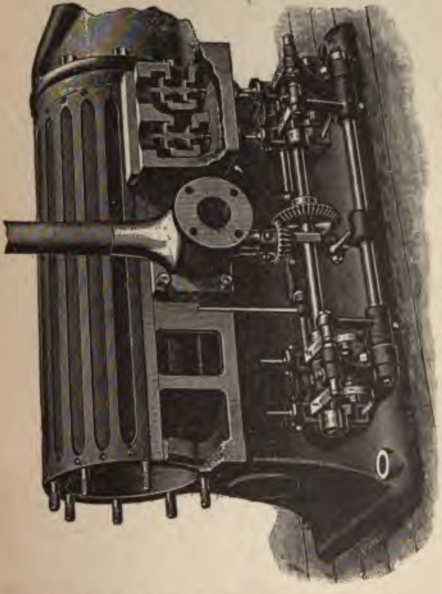


FIG. 129. THE PUTNAM VALVE GEAR.

gear *C* should be taken off and placed on the opposite side on the shaft, instead of

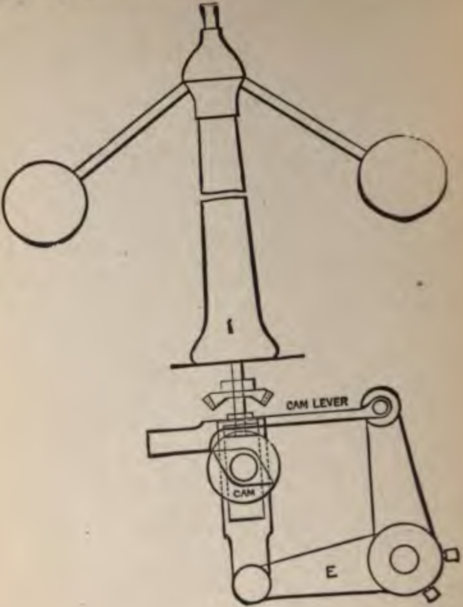


FIG. 130.

the collar *D*, and the collar *D* should be placed where the bevel gear *C* had been. This will be the right setting for the top of

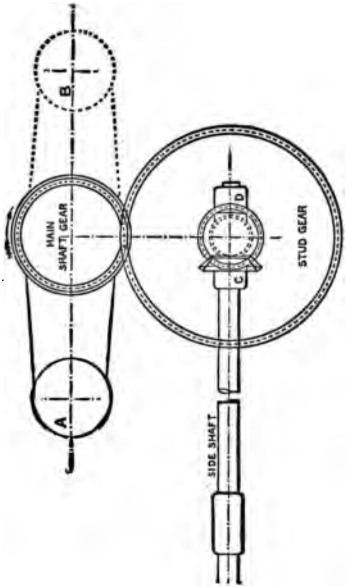


FIG. 181.

the fly wheel to run towards the cylinder.

Q. Before setting the valves of a Putnam engine, what should be done?

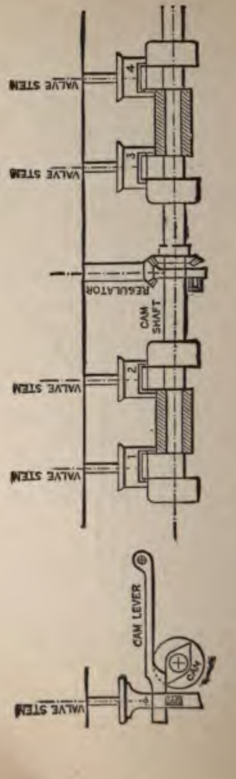


FIG. 132. PUTNAM VALVE GEAR.

A. Place the crank on the dead centre nearest the cylinder.

Q. In what order should the valves be set?

A. First, steam valve No. 2, then exhaust valve No. 4, then steam valve No. 3, and last, exhaust valve No. 1. See Fig. 132.

Q. How is steam valve No. 2 set?

A. Beginning at the cam No. 2, make a scratch mark or line on the valve stem (above the cam) $\frac{1}{16}$ inch below the packing box; then turn the steam cam No. 2 by hand in the direction shown by the arrow in Fig. 132 until it strikes the lever and raises it and the valve stem $\frac{1}{16}$ inch as shown by the scratch line. Holding it at that point, tighten and set screw in the cam, hard.

Q. How would you set exhaust valve No. 4?

A. Keeping the crank on the back centre, take exhaust cam No. 4 and set that valve in the same manner as valve No. 2 was set, excepting that the scratch line should be made $\frac{3}{16}$ inch below the packing box of the valve stem, so as to raise the valve $\frac{3}{16}$ inch; at which point tighten as before.

Q. How would you set steam valve No. 3?

A. Turn the fly wheel in the direction in which it is to run, until the crank reaches the dead centre farthest from the cylinder; then set the stem cam No. 3 in the same manner as No. 2, except that the scratch mark should be $\frac{1}{32}$ inch below the packing box, letting the valve rise $\frac{1}{32}$ inch instead of $\frac{1}{16}$ inch as with No. 2.

Q. How would you set exhaust valve No. 1?

A. Without moving the crank take exhaust cam No. 1, and set in the same manner and at the same height ($\frac{3}{16}$ inch) as for valve No. 4; in all cases making the set screws in the cams tight, when the valves are raised to the height as indicated.

Q. In case the regulator of a Putnam engine became unsteady, what should be done?

A. When this is the case, as may be seen by the balls of the governor dancing up and down rapidly, tighten up slightly two cap bolts on the rocker arm shaft, until the difficulty is overcome, (the caps bearing

this shaft are lined with leather for the pnrpose of giving more or less friction to shaft).

Q. What would be the effect of over tightening these caps?

A. The regulator would be held so that it would not respond quickly.

Q. In case the leather lining of these caps become worn by use, so that it will not hold the shaft sufficiently by friction, what should be done?

A. The caps should be taken off, and several thicknesses of paper put between the cap and the leather, then the caps replaced as before.

THE ROCKWELL ENGINE.*

Q. Why is the main valve of a Rockwell (Barney & Kilby) cut out more on the out end than on the crank end?

A. To equalize compression (the necessity arising from the angular distortion caused by the rods).

* Formerly Barney & Kilby.

Q. How would you proceed to set the valves of a Rockwell engine ?

A. Put the engine on its perfect dead centre, then move the main valve up to its proper lead (after equalizing its travel and length of rods), usually from 1-32 inch to 1-8 inch, depending on the size of the engine. After turning the engine over to prove the other end and making sure that the main valve is adjusted properly, again move the engine to its dead centre. Raise the double link up to its extreme travel and block it there for early cut-off or zero. Adjust the cut-off eccentric rod to travel the rock arm evenly on both sides its centre (this is very important as it will throw the link to cut-off later or earlier in the piston travel in proportion to its being out on either side of centre travel). Then throw the high part of the cut-off eccentric ahead of that of the main eccentric, from one inch to two inches (depending on the size of engine) in the direction the engine is to run, and fasten it there temporarily. Next, bring up the cut-off valve for that end of the cylinder, and set it just to close the

ports on the back of the main valve for zero at that end.

Turn the engine over to the opposite dead centre, and move up the cut-off valve just to close the port as before for zero at this end, all the while leaving the double link blocked up to its highest point.

Now take out the blocking, drop the link to its fullest travel, and move the engine around in the direction in which it is to run. Watch the valves, and when they cut-off, stop and measure the travel of crosshead on the guides (from marks previously made when the engine was on the dead centre). Move the engine around to the other end, bring to point of cut-off and measure on guides as before. This will give the latest point of cut-off, and in no case should it be later than the point of cut-off of the main valve (three-fourths travel).

This gives a preliminary setting of the cut-off valves.

Turn the engine around (having raised the link) and watch it at early cut-off.

Q. Should it occur that by not noticing the marks on the *eccentric* you have given

the cut-off eccentric too much advance ahead of the main eccentric, what would be the result?

A. The cut-off would occur too soon; in case the advance is insufficient the ports on the main valve would be left open throughout the entire stroke of the piston.

Q. After ascertaining that the early and late cut-offs are even, what next?

A. Raise the double link by inches and watch the cut-off at both ends of the cylinder, measuring the guides and comparing each end's cut-off with each inch in height of the link.

This is what is termed "setting the valves cold." They should be balanced up afterwards by the aid of the indicator, and with this in view the engine is so constructed as to make all adjustments from the outside.

Q. In case more or less compression is wanted to balance the reciprocating parts, how would you give it?

A. Move the eccentric ahead for more, and back for less, lead of the main valve. Both eccentrics should be moved exactly the same amount to keep the proper relation between the main and the cut-off valves.

ADJUSTMENT OF THE ROLLINS ENGINE.

Q. Give a general description of the Rollins engine?

A. This engine bears in its general make up some resemblance to the Corliss, but in many respects, especially in the matter of valve adjustment, is entirely dissimilar. Fig. 133 shows the steam side of the cylinder with the wrist plate, steam valve operating mechanism, steam chest, etc., and a section of the exhaust valve. Fig. 134 is a section through the cylinder showing the steam valve and port valve connections. The wrist plate, from which motion is transmitted to the valves, is upon one side of the engine, and the motion is transmitted directly to the steam valve through the rod and bell crank. This bell crank lifts a block which engages with a plate which is connected to the valve stem, and which on being raised opens the valve. Each of these pieces has eight wearing surfaces and may be changed as wear takes place. The latch that holds

the plate has an inclined tail piece extending below the crank on the governor shaft; and when it is raised enough to be touched by the pin upon this crank, the plate will be pulled off from the block and the valve, by means of gravity and the steam pressure due to the area of the valve stem, will close very sharply. The position of the crank is varied by the governor, according to the load and the boiler pressure, approaching the valve stem as the cut-off becomes earlier.

The exhaust valves are of the Corliss type, and get their motion from arms on the end of the wrist-plate shaft, which extends across the cylinder to which they are connected with right and left rods.

Q. How would you adjust a Rollins engine?

A. First see (as with a Corliss) that the rocker arm to which the eccentric rod is connected, swings to equal distances each side of a plumb line from its centre of rotation (making it do this, by lengthening or shortening the eccentric rod). Make the wrist plate travel to its

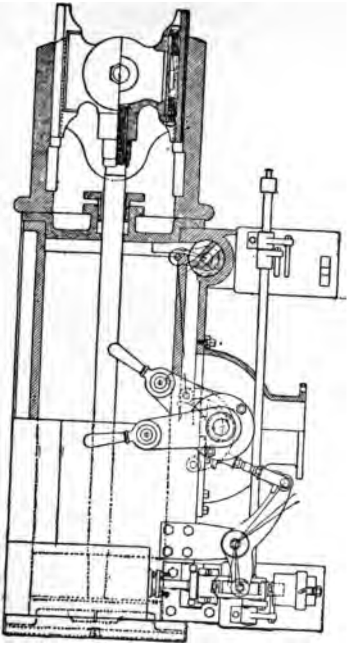


FIG. 133. ROLLINS ENGINE.

marks by adjusting the length of the hooked rod which connects the rocker arm with the wrist plate. Then the wrist plate should be put in its central position as with a Corliss. Then adjust the right and left

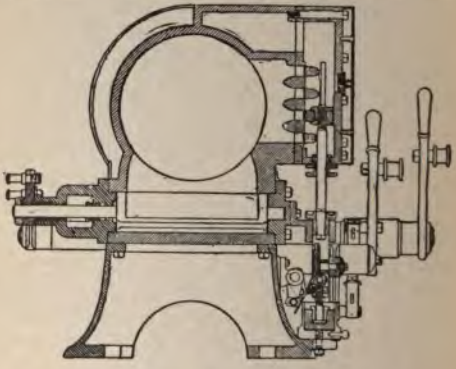


FIG. 134. ROLLINS ENGINE.

rods on the steam side, until the arms of the bell cranks move through equal spaces on each side of a line drawn at right angles to the valve stem to the centre upon which the bell crank turns. This being right and the movement being equal in

each direction, I would not attempt to adjust the opening or closing of the valves by them, as in the Corliss type, but would let them alone and turn to the adjustment of the valve upon its stem as in a slide-valve engine, screwing the valve stem back or forth in the nut in order to alter the relative position of the valve and its ports. When the wrist plate is on the centre, the valves will require to lap about one-quarter inch on the opening edge; and when they have been set unhook the valve, let it drop into the dash pot as far as it would go, and see that I had one-eighth inch lap on the top side, because if the valve was set so low as to open on this edge, steam would be admitted while the exhaust was open and while the piston was coming toward that end of the cylinder. Then with the rights and lefts on the exhaust side I should set the valve cranks so that the marks upon the cranks coincided with those upon the bars upon which they turn when the wrist plate is in its central position. If these marks are not apparent I would set each valve so that it was just

square with the edge of the port when the wrist plate was in its central position. Then I should turn the engine hook on the wrist plate, and set the eccentric so that the steam valve on the end which should be taking steam would be open about one thirty-second of an inch. If I am accurate in the previous work I will find that upon turning the engine over to the opposite centre, the other valve will have the same amount of opening.

Q. How can you balance the load between the ends and the cylinder?

A. By turning a little screw which will be found upon the head end governor crank. By turning it in one direction or the other, it will be found that the cut-off of the head end may be lengthened or shortened to match that on the crank end, and the load on the engine thus equalized.

Q. Suppose that on applying the indicator the engine is found too early all around, what should be done?

A. The eccentric should be set backward.

Q. How are the points of release and compression governed?

A. By the adjustment of the exhaust valve.

Q. How can the exhaust be made to take place earlier?

A. By shortening the right and left connecting rods.

Q. What other effect will this have?

A. To diminish the compression.

Q. What would be the effect of lengthening the right and left connections?

A. To give a later release and more compression.

Q. Describe the principal features of the valve motion and cut-off gear on the Rollins automatic engine?

A. The wrist plate from which motion is transmitted to the valves is upon one side of the engine, and that the motion is transmitted directly to the steam valve through a rod and bell crank. The bell crank lifts a block, which engages with a plate, which is connected to the valve stem, and which on being raised, opens the valve. Each of these pieces has eight wearing surfaces and may be changed as they become worn. The latch which holds the plate has an

inclined tail-piece, extending below this crank, on the governor shaft, and when it is raised sufficiently to be touched by the pin upon this crank, the plate will be pulled off from the block, and the valve, by means of gravity and the steam pressure due to the area of the valve stem will close very sharply. The position of the governor shaft crank is varied by the governor according to the load and boiler pressure approaching the valve stem as the cut-off becomes earlier.

The exhaust valves are of the Corliss type and derive their motion from arms on the end of the wrist-plate shaft, which extends across the cylinder, to which they are connected with right and left rods.

THE RUSSELL SINGLE VALVE AUTOMATIC ENGINE.

Q. Give instructions for setting up a Russell single valve automatic engine?

A. The engine is first placed in its proper position and levelled lengthwise on small supports, such as small pieces of iron or

strips of hard wood. Remove the cap from main bearing and clean thoroughly, removing paint from end of bearing to prevent tightness between disc and collar. See that all roughness is removed from journal and that it is perfectly clean, then place shaft in bearing and replace cap, leaving out the liners, and screw up tight, allowing the outer end to rest on an upright post or on blocking with a piece of iron, well oiled, placed under the shaft to allow it to take its position laterally. When properly tightened, place the shaft in a level position, allowing the engine bed to swing on the wedges at each end. Place the level (if a Tangye bed) across the lower guides and level bed by means of wood or iron wedges and screw down nuts on foundation bolts. Now remove the sole plate from outer pil low block and place on outer foundation. Remove the liners from pillow block and see that journal and bearing are clean; then place it on the shaft and screw the sole plate fast to it and clamp in position by screwing down the cap; place wedges under, just sufficient to hold it in position.

Bed with sulphur or cement. After the bedding has become well set, tighten the foundation bolts thoroughly, and while doing so keep continual watch of the lever and know that you are drawing no part of the engine from its previous levelling. Remove journal caps and shaft, put on governor and fly wheel, replace shaft, put in liners and adjust caps so shaft turns easily.

To verify the squareness of the shaft, place the crank pin either at back or forward centre and draw a line from the exact centre of cross-head pin to the centre of crank pin, then revolve the disc until the pin is on opposite centre, and if the line passes over same point the setting is correct.

In connecting the engine, place the eccentric in position on eccentric yoke and move the governor case on shaft until the eccentric rod touches the rocker arm at point of attachment; remove rocker arm wrist and connect. Insert feather in governor and tighten set screw, seeing that it does not move from position while so doing. See that the marks on jam nut and rod are to-

gether; when the valve will be properly adjusted. Remove cap from end of crank pin and connect that end first; clean all oil holes and remove all grit or paint from all exposed wearing surfaces on engine and governor. Blow out all steam connections thoroughly before connecting to engine permanently, and be sure no dirt has entered the valve or cylinder. Oil thoroughly and turn the engine a few revolutions by hand before turning on steam.

Q. What instructions are appropriate for operating and adjusting a Russell single valve automatic engine?

A. Before starting, see that all oil cups are feeding and all wearing parts thoroughly oiled, and make sure that the cylinder lubricator is working. Open all drip valves and relieve all condensation in the pipe before turning on sufficient steam to run the engine; then close the valve at bottom of the steam chest and start the engine slowly, and as the speed increases if the valve slaps, admit steam to back of it by the small valve above the steam chest. Great care should be taken in operating this valve, as it ad-

mits excessive pressure on the back of the valve and should never be opened more than sufficient to keep the valve quiet. After the governor takes control of the engine, close the small valve as much as it will admit and keep watch of it as the engine runs—never allowing the pressure to accumulate; as the valve becomes heated, it will take its proper shape and no steam will be needed on the back other than is provided for in itself. Should the small valve be left open and excessive pressure accumulate, the attention would be called to the noise in the governor and vibration of valve rod, which should be relieved immediately. In stopping the engine, as soon as the throttle is closed, open valve under steam chest to relieve pressure from the back of the valve; should this not be done, the valve connections will show heavy working of the valve, caused by the steam being taken from under the valve, leaving balance pressure on the back.

Q. What instructions are desirable as regards the governor?

A. The governor is so constructed that

all wearing parts may be adjusted by means of two gibs or keys. On the inner side of the main eccentric, next to the bed, will be seen two screws that pass through slotted holes into the key that holds the main eccentric to the brass hub plate. By loosening these screws just sufficient to allow the key to be driven, all looseness or wear on that part can readily be taken up.

At one end of the main eccentric projections will be seen two screws passing through slotted holes in the casting into the key for adjusting the inner eccentric. By loosening these screws the key may be driven in, and by so doing take up wear on ends of inner eccentric as well as the eccentric itself, as will plainly be seen from construction of these parts.

Care must be exercised in tightening the keys, and it would be best to tighten only one at a time, so that should it be too tight and cause the engine to race or run above its proper speed, it will be easy to determine where the trouble is. The key that adjusts the inner eccentric, if properly

tightened, will remove all noise in the governor.

Should the governor race, release the tension on the springs very little at a time until the governor works smoothly, using care to keep the tension of the springs the same.

Q. How may the engine speed be increased?

A. By taking off one or more thin plates from the governor weights (keeping the weights equal on the two arms).

ERECTING AND ADJUSTING A SHAPLEY ENGINE.

Q. How would you set up a Shapley engine which had been taken down for shipment?

A. First place the base, and on it the cylinder, with packing; then the column; next the brace connecting them; then place the boiler, with feed water-pipe in, using cement sent to make the joint under the boiler; (the same cement is used with the jacket.) Care should be used in placing

these parts. Dowels are provided for cylinder and column. Use white lead to make all screw steam joints. All steam chest covers are ground on, and need no packing or leading. All bolts and parts are marked for their proper places. Use care in packing around the rods, especially the pump, which should always be allowed to run as loosely as practicable; also the governor stem, to avoid undue friction, which would cause it to work badly.

Have a good firm foundation for the engine to stand on, then secure it so as to keep it in place, after setting in line with machinery to be driven; level by main shaft and plumb by guides, when all parts are put together.

Q. How is the eccentric of a Shapley engine set to run the shaft; and how may the engine be reversed?

A. The eccentric is set to run the engine right-handed, but may be reversed by turning the eccentric so that the mark on it will agree with the other mark on the shaft.

Q. What precautions are necessary in

starting, and what general directions apply as regards running?

A. Be sure to open the lower cock in cylinder to draw off the water before starting; also, never start the engine without the stop-valve between the heater and boiler being open. The feed water to the pump should be regulated so as to supply the water as near continuously as possible. The water in the boiler should not be run too high, as it would necessitate much heavier firing, and would "prime," or draw over into the cylinder, thence through the exhaust into the base, and if allowed to collect would shut off the draft. Keep the flue in base nearly clear; holes are made and pipes screwed for that purpose. To clean the flues, remove the jacket; and make the joints tight in replacing them by using some kind of cement.

Q. How may the speed of the engine be changed?

A. By raising or lowering the valve, by means of the screw which passes through the ball at the top of the governor, connected with the arms, and secured by a jam

nut after being arranged properly. A small screw in the upper end of the stand around which the sleeve of the governor revolves, is used for cutting off the steam so as to prevent vibration in the motion of the engine; unscrew a very little, if it cuts off too quick or shuts by too far, so as to cause irregular motion. Sometimes it become necessary to take out the governor valve and clean it, and also clean the seats.

THE STEARNS ENGINE.

Q. How would you set up and adjust a Stearns engine?

A. The foundations and bolts for engine bed and crank shaft outboard bearing having been prepared according to template and drawings furnished, I should set the engine bed and bearings in their places; level each with the other and bring both in line for the crank shaft and make this alignment true with the main line shaft or counter shaft; level the spot on the crank end of the cylinder by a steam chest or governor flange, the frame by the guides,

both longitudinally and laterally ; level between the engine and foundation by small iron wedges capable of supporting the bed in place while the sulphur, lead, or cement is run in. This done, the shaft being in place and the level again tested, I shonld run liquid cement, melted sulphur, or melted lead in the space between the top of the foundations and the bed plates, and sole plate, and allow it to harden; after which, I should screw the nuts down on the foundation bolts, set the crank shaft and band wheel in place, and put on the connecting rod and eccentric rod, driving the keys up to the marks at the upper sides; connect the throttle valve and governor to the steam chest and the steam pipe to the boiler ; connect the exhaust and waste pipes, and attach all oil cups.

SETTING UP A "STRAIGHT-LINE" ENGINE.

Q. How would you proceed to set up a Straight-Line engine?

A. If the engine was one of the smaller sizes, fifty horse-power or less, I would take

it all apart and clean it, noting the exact position in which each part was set, so as to return it to its proper position. I would

FIG. 135. CHEEK PIECES "STRAIGHT-LINE" JOURNAL BOXES.

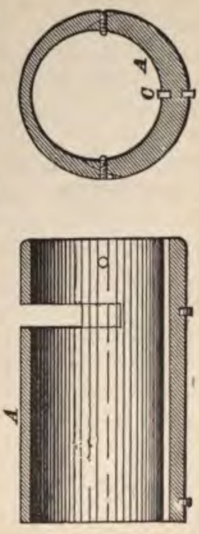


FIG. 136. SLEEVE, "STRAIGHT-LINE" JOURNAL BOXES.

then remove the frame and pedestals from the base plate and have that bedded in cement on the foundation and set level, tak-

ing special pains to keep the bolts free and have the cement bear the heaviest under each of the three pedestals. I would then set the frame and pedestals on the plate and tighten down the nuts on the four hold-down bolts and test the frame with the spirit level by placing a straight edge through the main boxes when they are in the frame.

Q. Why is it necessary to have the engine level through the main bearings?

A. Because the shaft has end play in the main bearings; and if the engine is not level the wheels will run on one side and the benefit of the free end play will be lost.

Q. What is the object of free end play?

A. It keeps the main bearings, crank pin, and crosshead pin from wearing in streaks or cutting.

Q. If you do not find the frame level, how would you level it up?

A. By packing with pasteboard or paper under the wood packing pieces in the top of pedestals.

Q. Why are wood packing pieces used between the pedestals and frame?

A. The wood pieces are elastic and rounded on the under side, so that tightening the bolts will not cramp nor twist the frame and thus cause the bearings to heat.

Q. Do you level the engine lengthwise, and if so, how?

A. No; no more than is done when the plate is set, as it is of no consequence whether it is level endwise or not.

Q. What next in setting up the engine?

A. From choice I should next proceed to put in the wheels, first cleaning and putting in the connecting rod by removing the box cap and passing the small end through between the arms of one wheel and then passing it through between the two wheels; then putting on the cap. I should then put on the main boxes, and jack or roll the wheels into place. (While jack screws are the most convenient to raise the wheels, if they are not available, a plank can be laid down and the wheels rolled on it, to bring them high enough to go in.) After the wheels are in place the lead rings for oiling the bearings should be put in (first withdrawing the brass wedges in box), then

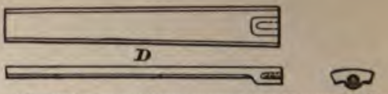
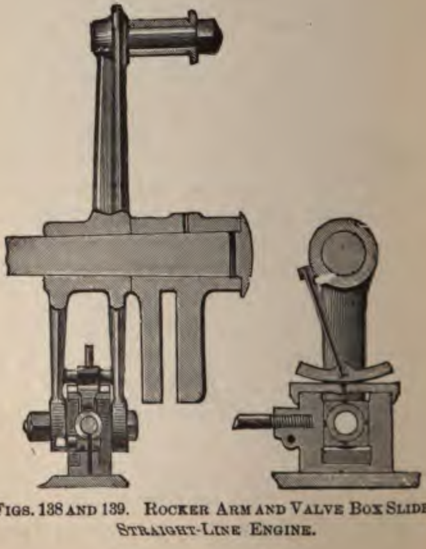


FIG. 137. WEDGE OF STRAIGHT-LINE JOURNAL BEARING.



FIGS. 138 AND 139. ROCKER ARM AND VALVE BOX SLIDE, STRAIGHT-LINE ENGINE.

putting in rings and driving the wedges back to place, and setting down the set screws.

Q. What is the most delicate point to observe in doing this work?

A. Special care must be taken not to bend the lead rings, as the whole success of their action depends upon their being true. To prove that they are all right I should roll the wheels over two or three times, and see that they revolved with the shafts.

Q. Is it necessary to do anything to the governor when setting up the engine?

A. No; the governor comes adjusted and there are no bearings that can get injured in shipment or that will need cleaning.

Q. What next?

A. It makes no difference whether the attachments to the piston or those of the valve are connected next; although naturally one would put in the crosshead and connect it to the connecting rod. The crosshead can be rested upon a board laid across the frame, and the crosshead pin put in and bound fast by the tightening screw.

Q. What is the special difference between

this engine and others in respect to the crosshead and pin?

A. The crosshead is very much longer than others; equalling or even exceeding the stroke of the engine. The crosshead pin is made fast in the rod and turns in two bearings in the crosshead.

Q. How is it possible to tell when the boxes are set right when there are two of them on the pin?

A. Set both boxes up tight and then slack back each an equal amount until the connecting rod will move freely from side to side with the hand alone or aided by a short "pry" like a hammer handle.

Q. What do you mean when you say from "side to side?"

A. There is one-eighth of an inch play between the connecting rod and the crosshead; and by prying on the rod the crosshead is made to slide or has end play in the boxes.

Q. What about coupling the piston in the crosshead?

A. There are two methods used; one where a half nut is bolted up to grip the

rod by binding bolts. In either case the rod is marked to show which side shall go up, and what number of threads should be left, showing when the crosshead is in place.

Q. Why must the piston be set a certain side up?

A. Because the piston rings do not go all around and the space must be placed on the bottom.

Q. What care is necessary in putting on the cylinder head and steam chest cover?

A. None, if it is a new engine, except to wipe them clean and avoid all grease or oil.

Q. What harm would oil or paint do?

A. None for that once; but it will burn on, and when it becomes necessary to put the cover on the next time, the burned oil would have to be scraped off, which would ruin the job.

A. Why do their joints need any different treatment than those of other engines; and what is the object?

A. Because they are made differently; and if used as the instructions call for no

packing should ever be needed. They can be taken off and put on any number of times, and come tight if screwed up uniformly.

FIG. 140. THROTTLE VALVE, STRAIGHT-LINE ENGINE.

FIG. 141. "STRAIGHT-LINE" GOVERNOR LINK PIVOT.

Q. Should anything be done before the valve is put in?

A. Yes; the steam pipe should be put up

and thoroughly blown out with steam before the valve is put in and the chest cover put on. After the pipe has been thoroughly blown out (which it might be well to do before the piston is put in), the valve can be put in and coupled to the eccentric; no adjustment being necessary unless the valve rod has been removed; but if it has, it can be reset by a gauge which is sent with the engine.

Q. In starting the engine, what precautions is it advisable to take?

A. To start slowly so as to see that everything is right; and also to let the water pass out and the cylinder warm up.

Q. What precautions when running?

A. To see that the throttle is full open, and the cylinder lubricator working; and that all bearings get oiled.

Q. What precautions after shutting down?

A. To see that all the oil collected in the fly-wheels is removed and the engine wiped all over.

Q. What about the larger sized engines?

A. They differ somewhat from the smaller sizes, but not so much but that a skilful

mechanic should be able to set up one from these instructions and those sent.

Q. What would be your advice to an engineer who never handled one of these engines?

A. To read carefully the descriptions and instructions and to learn all possible about the engine; and if there seemed to be trouble to be sure and find out the true cause before attempting to remedy it. In other words, if you cannot decide on the trouble with the builders, NEVER EXPERIMENT.

Q. "There is a Straight Line engine which thumps every time she turns over. On taking it down it was found that the pivot bearing of the governor arm (this arm turns on a pin in a bushed hole in one of the fly-wheel's arms) had considerable lost motion, and the pin was rattling in it. The pin was worn upon one side; the bush has means of taking up its own wear, but it was not worn, and there would not, anyhow, have been enough take-up for all that play. The play must have been intentional or accidental, at the time of making the

engine; it is evidently not the result of wear. Another thing is that there is no oil-

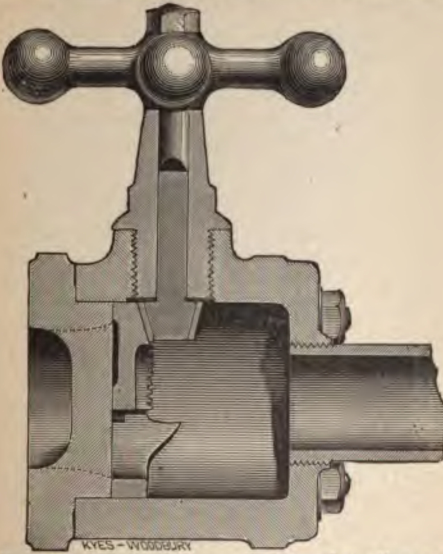


FIG. 142. THROTTLE VALVE, STRAIGHT-LINE ENGINE.

hole provided for this bearing. Was that intentional or accidental? The pin has at one end *a tit which* engages in any one de-

sired of four depressions, so that the pin can be turned one-fourth way around when desired, but cannot turn of itself. This pin fits tight in the lever, the rattle is only in the hole in the fly-wheel arm. Please give some points upon this case." *

A. The hole was intentionally made too large, and the oil-hole was purposely omitted. The governor spring is probably too weak; it should keep the pin snug up against one side of the bushed hole. And the action of the ball should be to make that side of the pin which is in contact with the bushed hole roll upon the hardened bush—something like the scale-beam principle. In fact, some of these engines are made with knife-edge bearings instead of pins, and flat steel plates instead of the bushes; and sometimes they will be found with knife-edges bearing in hardened V's.

Oil would be likely to clog the action of this balancing motion. In your case, strengthen the spring, else either get a larger pin or a smaller bush; and if you

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* Question which came by mail to the author.

change the fit of pin and bore, of course provide a means of oiling.

ADJUSTING THE TWISS ENGINE.

Q. How would you proceed to set the valves of a Twiss autcmatic engine?

A. Remove the back bonnet, and there will be seen two marks on the bore of the seat, the upper one coinciding with the steam edge, and the lower with the exhaust edge of the steam port. Upon the ends of the main valve driver there will be seen two marks, the upper one of which coincides with the steam edge, and the lower one with the exhaust edge of the main valve. Adjust the length of the connection between the two main valve cranks so that these cranks shall both stand in a vertical position. In this position of the cranks, about three-quarters of the total lap of the main valves will be on the steam side, and the other quarter on the exhaust side of the steam port. Adjust the length of the main eccentric rod so that the main valves will travel equal distances each side of a central

position, and place the main eccentric 90° back of the crank (when the engine "runs over"), and from this position move the eccentric forward in the direction in which the engine runs, the amount of the steam lap and about one thirty-second inch more for lead. Secure the eccentric in that position. Then adjust the connection between the cut-off valve cranks, so that they will both stand in a vertical position. When all the valve cranks stand in a vertical position, or all the valves in a central position, the cut-off valves will be open an amount corresponding to the steam lap of the main valves; so that if the cut-off valves were held stationary in the central position, and the main valves were moved the amount of either steam lap, and were just beginning to open, the cut-off valves would be just closed. The link block should next be placed at the centre of oscillation of the link, and the rod connecting it with the cut-off valve cranks adjusted so that both the cranks will stand in a vertical position. The cut-off valves are now set to cut-off at zero, and the en-

gine should cut-off at zero at both ends of the cylinder.

Q. How can it be proved whether or not the engine cuts-off equally at both ends?

A. By putting the engine first on one centre and then on the other, and observing the marks which may be seen, one on the cut-off valve crank, and the other on the main valve crank. When these marks are together, or "line and line," the cut-off valve is just closed.

Q. Suppose that the cut-off is not the same at both ends, what should be done?

A. Adjust the link rods until both ends are alike.

Q, What is the next thing to be done?

A. Place the cut-off eccentric about 30° in advance of the main eccentric, and secure it in that position; connect the cut-off eccentric rod with the link (if it has not been connected); place the link block at its furthest position from the centre of oscillation of the link, and in this position connect it with the governor rod when the governor is down. Turn the engine around and note the distance that the piston has

travelled from each end of the cylinder when the cut-off valves have just closed.

Q. Suppose that both ends do not cut off alike at this stage, what should be done?

A. They should be equalized by lengthening the cut off eccentric rod where the crank end of the cylinder cuts off the latest, and shortening when the back end cuts off the latest.

Q. Suppose that the engine cuts off earlier than one-half stroke when the governor is down, what should be done?

A. Move the cut-off eccentric back a little toward the main eccentric.

Q. How would you make the engine cut off earlier when the governor is down?

A. Move the eccentric ahead a little.

Q. How are the valves usnally set?

A. To cut off from zero to half-stroke.

Q. May this range be increased?

A. Yes.

Q. How may the speed of a Twiss engine be changed while the engine is running?

A. By adding or removing governor weights.

ERECTING AND ADJUSTING A WATERTOWN AUTOMATIC ENGINE.

Q. In erecting a Watertown automatic engine,* is there any special point to consider in commencing?

A. The form of bed and its relation to main pillow block and guides require that proper attention should be given to levelling of the frame upon its foundation; and as it is nearly impossible to prepare a foundation which shall be so level on its surface as to be ready to receive the frame, other means must be resorted to, to insure this result.

Q. What is the best method of accomplishing this?

A. After placing engine upon foundation, and seeing that all anchor bolts are properly adjusted in bolt holes, take off main pillow-block cap and place a level on shaft bearing in the pillow-block, and by means of small iron wedges driven in from outside and inside of frame, make this pillow-block per-

* See description, *page 71.*

fectly level. From this as a starting-point, adjust the frame from end to end, driving in the iron wedges both inside and outside at each bolt hole, as may be required.

Q. What about levelling the guides?

A. Particular attention should be given to levelling the guides in this same manner, as the proper working of the engine depends largely upon the guides and pillow-block being exactly parallel in all respects.

Q. When this has been accomplished, what is next in order?

A. Clay can be placed at inside and outside of frame at the top of foundation, leaving at different points near bolt holes, opportunity to pour brimstone, which, filling between bottom of frame and top of foundation, will make solid bearing for frame at all points.

Q. When this has been done, what next?

A. Shaft may be placed in main pillow-block, and cap put on and screwed down solid, binding shaft firmly in main pillow-block.

Q. From what line has the engine been tried by the makers?

FIG. 143. WATERTOWN ENGINE.

A. By examining inside of frame on opposite side from pillow-block, it will be discovered that frame has been planed its entire length, and from this line all parts of engine have been made parallel; and as crank disc has been faced on crank, by using calipers from inside of the frame and side of crank disc at each side of its diameter, shaft can be made at absolute right angles with frame.

Q. Is it necessary in lining crank shaft to put line through centre of cylinder and guides as is usually done by many engineers?

A. No; the line of frame which is placed as before mentioned is an absolute line to work from.

Q. When crank shaft has been squared and made perfectly level with frame, what is to be done?

A. The outboard pillow-block (after removing cap) can be placed at outer end of frame and blocked up securely against bottom of shaft with iron wedges, as used in frame itself. This proceeding places crank shaft, out-board pillow block and main frame in their proper relation to each other.

Q. The next step ?

A. Shaft can now be removed, fly-wheel put in place therein, and shaft replaced again in its bearing, when it is ready to receive eccentric straps and rods.

Q. How about attaching eccentric straps and rods ?

A. No particular directions are necessary for properly attaching eccentric straps and rods, only care should be exercised in not making them too tight at the start. It is better for a little looseness to be discovered for the first few days' running than to make them tight at first, and cause permanent injury by consequent overheating.

Q. How do you attach connecting rod ?

A. Put box on crosshead, attach strap and put in bolt and drive the key, leaving crank end detached ; take hold of connecting rod and operate it to discover whether key has been driven tight enough. Continue driving key until it is found that box comes to a proper bearing, being sure to leave plenty of looseness, that no heating may occur when engine is started. Then with knife point or fine scratch-awl make a

mark on the key just at top of strap, which will determine point at which key should be driven when connected for use. Disconnect connecting rod from crosshead end and attach to the crank pin. Try crank pin connection in same way, driving key and marking at top of strap in same manner as mentioned at crosshead end. When this is done, connection can be again made to crosshead, keys driven to the marks before made and connecting rod will be properly attached.

Q. How about tightness of connecting rod brasses ?

A. It is the maker's intention that when keys in connecting rod are driven up so that brasses are right on pins, the two halves of brasses should be solid together on face ; and brasses should never be filed apart for running, as the oil from cups will run from the pins out of the openings in the brasses, and its effect on the pins will be lost.

Q. If necessary to tighten brasses to prevent thumping, what should be done ?

A. Just enough should be taken off from

the brasses so that when key is driven home they will be solid together as they were sent from factory.

Q. In packing valve rods, what is well?

A. To fill stuffing boxes nearly full, using care in tightening the gland not to press packing so tight as to bind on the valve rod.

Q. Why?

A. Because this would cause unnecessary friction and prevent proper working of the governor.

Q. What about the governor belt?

A. At first it should be attended to daily to see that it does not stretch and slip on pulley enough to prevent governor from raising readily on the governor stem; a fruitful source of irregularity of speed when not properly attended to.

Q. What should be done with piston rings?

A. The piston rings in cylinder are always properly adjusted before engine is sent out from the works, and if cylinder is sufficiently oiled, engine may be run for considorable time without any adjustment of rings.

Q. How about alteration of adjustment of engine when renewed?

A. All working parts of these engines are adjusted and fitted before engine is sent from factory; and no changes should be attempted by any engineer, in adjustment of either governor or valves. But any seeming defect should be reported to the factory for explanation or repair, if such should be thought to be actually necessary.

Q. How do you increase the speed of the Watertown engine?

A. By moving the weight on the speed bar.

Q. How do you make cut-off earlier on both ends of the same engine?

A. By advancing the eccentric.

Q. How would you make cut-off earlier on crank end only?

A. By shortening the eccentric rod.

Q. How would you make the exhaust release earlier on both ends?

A. By advancing the eccentric.

Q. How would you make exhaust release earlier on crank end only?

A. By shortening the eccentric rod.

Q. How would you make cushion earlier on both ends?

A. By advancing the eccentric.

Q. How would you make cushion earlier on the crank end only?

A. By advancing the eccentric.

Q. How would you increase the lead of the Watertown engine on both ends?

A. By advancing the eccentric.

Q. How would you increase lead on crank end only?

A. By lengthening the eccentric.

Q. What adjustments can you make on the Watertown engine without affecting any other adjustments?

A. Only the speed. In all other quarters, changing one item changes all the rest. Thus, advancing the cut-off advances the lead, the release, and the cushion.

SETTING UP AND ADJUSTING A WESTINGHOUSE ENGINE.

Q. Give a full description of how you would proceed to set up a Westinghouse engine, if every piece were separated from the others?

A. Take the crank shaft, insert it through the open end of the crank chamber and into the main bearing at the opposite end; put on the loose crank box head and bolt it with its main bearing in place; put centre bearings under the middle of shaft in the interior and pull it to place; take the pistons, insert the connecting rods in them, pass the pins into the holes in the piston heads, spring in the rings into the piston heads; insert the pistons into the cylinders from above; connect the lower end of the connecting rods by means of their straps to the respective crank pins; take the valve guide, insert the eccentric rod into it, pass the pin through the hole in the guide, spring the rings into place, slide on the piston valve over its stem and screw down the jam nuts to hold the valve from moving on the stem up and down, but not so as to cramp it from adjusting itself in the steam chest; insert the whole valve gear, eccentric rod first, down through the steam chest, passing the lower end of eccentric rod into proper place in the strap, and key it home; put on cylinder covers, after thoroughly

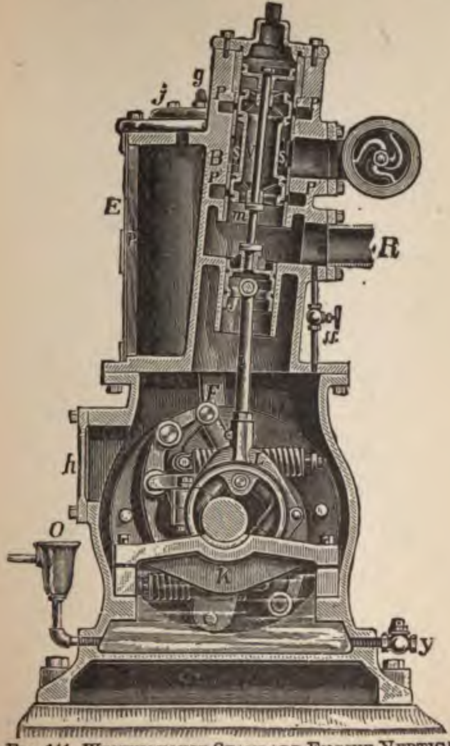

FIG. 144. WESTINGHOUSE STANDARD ENGINE, VERTICAL SECTION.

wiping out cylinders and pistons to remove all dirt or grit, and lubricate them ; put on the steam chest cover and connect the steam and exhaust pipes : put on wheels on the ends of shaft, insert the keys into the key seats and pull down firmly the set screws which hold the keys in their place ; pour in clean water from the open side of crank chamber until it rises to the height of overflow, at which point the wrist pins of the crank will be plunged into the water at every revolution ; pour in a sufficient quantity of Crankcase oil, and put the crank box cover in its proper place and bolt home tightly. Before starting, see that the automatic lubricator is ready to work ; drain the cylinders thoroughly from water, and allow the engine to be somewhat heated by the steam.

Q. How do you increase the speed of a Westinghouse engine ?

A. As the engine is controlled automatically it would be necessary to make a change in the cut-off gear to increase speed. A heavier pair of governor springs or a lighter pair of weights will enable the engine to run

faster. Usually the weights are made with a provision for a slight change, as there is a pocket containing lead in each weight,

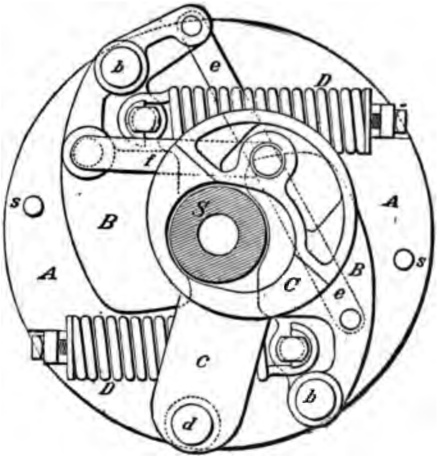

FIG. 145. WESTINGHOUSE GOVERNOR.

and this lead can be removed for the purpose of increasing speed.

Q. How would you make this engine run slower?

A. By putting in lighter governor springs or heavier weights.

Q. What effect would increased spring tension have upon the speed?

FIG. 146. WESTINGHOUSE GOVERNOR.

A. A slightly increased spring tension will make the engine run faster; but any considerable amount of additional tension will slightly cause the engine to "saw," that is, to run now fast, now slow, and

cause the governor weights to slam in and out so as to destroy the engine's efficiency. The principle on which these governors are built is that of equilibrium between the tension of a spring and the so-called centrifugal effect of a flying weight. To increase tension beyond the proper point destroys the equilibrium.

Q. How would you make a Westinghouse engine cut off earlier?

A. As the point of cut off is determined by the automatic regulator, it cannot be made to cut off any earlier, for a given load, than it does; neither can it be made to cut off any later than it does for a given load, unless on account of a change in condition, such as back pressure, etc.

Q. How do you make exhaust release earlier?

A. This cannot be done without a change in the valve itself, as the governor also controls the point of exhaust release.

Q. How is cushion made earlier?

A. This point, also, is determined by the governor, and is variable for different loads.

Q. How do you increase the lead?

A. The only way is to make a change in the valve, using less steam lap; and this, for a given travel of eccentric, also has the effect to cut off later.

In general, the Westinghouse engine is built so that no variations or adjustments are allowed in or about the governor, except the matter of spring tension.

Q. If the puffs of exhaust on a Westinghouse engine are unequal, what is the cause?

A. The valve needs resetting; and it will usually require to be raised on the stem, because in a single acting engine the wear is always downward, so that after a long use the effect of wear will always be to drag the valve downward, never to raise it.

Q. How would you set the valve?

A. Remove the cylinder covers, open the throttle just a hair, turn engine forward, and measure with a rule the position of each piston when steam is admitted and cut off. Raise the valve on the stem by placing washers under it until the point of admission is the same in both cylinders, and the point of cut-off will also be the same in both

cylinders, and by measuring both for admission and cut off, one measurement will check the other and prevent mistakes.

Q. If oil runs out of the main bearings, how would you stop it?

A. If the oil runs out past the lead ring between the crank case and main bearing flange, simply tighten up on the studs which draw the main bearing shell into the crank case head. If oil leaks between shaft and main bearing flange, it may be due to the following causes: First, the oil hole which returns the oil from end of main bearing to the crank case may be plugged and should be cleaned with copper wire. Second, the oil and water may be too high in the crank case, and if lowered the leakage will stop. To lower it, put a shorter nipple between the crank case and overflow cup. It is at the proper height when the crank pin is two-thirds submerged at the bottom of its stroke. Third, and most important, leakage may come at the end of main bearings because the vent pipe to the crank case is stopped up and should be cleared.

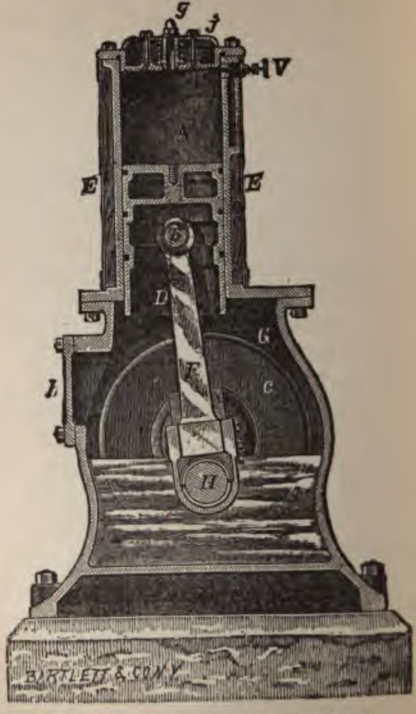

FIG. 147. WESTINGHOUSE, 5 TO 25 H. P.

Q. Why does the stopping of the vent pipe cause this leakage?

A. Because it allows the vapor in the crank case to accumulate and form a slight pressure which will naturally force the oil and water out of any opening in the crank case which is near the surface of the water. The keeping of this vent free and always open to the atmosphere is one of the most important items in the running of this build of engine.

Q. Is there any other possible cause for leakage in main bearings?

A. Yes; in very rare cases the washer on the shaft just within the flange of the main bearing shell may have been left off at some time when the engine has been apart, and thus there is nothing to keep the oil and water from working along the shaft and being thrown off by the fly-wheel hub. It is, of course, remedied by putting the washer back where it belongs.

Q. How do you detect leakage of steam in the valve?

A. Remove the valve chest cover and run the engine very slowly under steam. If

there is leakage between the puffs of the exhaust, it will be easily noticed.

Q. How do you correct leakage in valve?

A. Put on a new set of valve rings, but do not try to patch up old ones.

Q. How do you detect leakage of steam past the pistons?

A. This is very simple in a Westinghouse engine, as the lower ends of both cylinders are open to the crank case, and if any steam blows through it is instantly noticed.

Q. Would you expect to find leakage frequently or in any large quantity in this form of an engine?

A. No, because the pistons are so long that it is very hard for steam to get by them even if the piston rings were out of order.

Q. If a gale of steam seemed to be blowing out of the vent to the crank case, how big a channel would you expect to find it coming through between the piston and cylinder?

A. So small that it could scarcely be noticed, for an opening so small as to be hard to find will blow a very large quantity

of steam at pressures commonly used in engines.

Q. What practical point do the above facts teach regarding the leakage of pistons?

A. That in any engine leakage past piston cannot be judged by looking at the piston and cylinder, and supposing that because they look right steam does not blow by them. The only test worth having is a steam test under actual working conditions with the piston moving.

Q. If steam is seen blowing from the crank case vent, is it evidence that the pistons are leaking?

A. No; in nine cases out of ten bad oil is being used in the crank case, allowing the parts to heat and boil the water, which escapes as vapor from the vent.

Q. What is a sure indication of this?

A. More than ordinary wear on the parts, and loss of water in the case by its boiling away.

Q. What kind of oil can cause this?

A. A light, refined, high grade, expensive oil, or an extremely low-grade, gritty oil.

Q. What is the proper oil for a Westing house engine?

A. A heavy-bodied, black oil which will not evaporate, that the company has prepared specially for this purpose.

Q. What is the most dangerous experiment to try with the Westinghouse engine?

A. Experimenting with all sorts of oils, instead of taking the manufacturer's advice as to what oil has proved to be the best for use in the crank case.

Q. How do you know when a Westinghouse engine is seriously overloaded?

A. By the governor weights bumping on the shaft.

Q. How much load is on it when the steam is 80 pounds and the weights bumping on the shaft?

A. About 25 to 30% above its rated capacity, and the weights are not cushioned to reduce the noise of bumping, as it is desirable that this should be a warning that the engine is being overloaded.

Q. Why should the Westinghouse engine be started very slowly?

A. Because it is very quick at starting,

and therefore requires extra care to prevent its starting too rapidly. This is due to small internal friction and the fact that the wheels are necessarily lighter because of the high speed at which the engine runs.

Q. Why should it be stopped very slowly; in fact, slower than is common with other engines?

A. Because a single acting engine depends on compression to take up whatever lost motion may be in the reciprocating parts, and with steam shut off and cylinder cocks open, this compression is lost. Therefore the engine will be noisy during the time it is running by momentum of its fly-wheels with steam shut off. Stopping it very slowly almost entirely prevents this.

Q. How should repairs be made on Westinghouse engines?

A. Entirely by duplicate parts, as the design of the engine is such that by replacing small parts as they may wear keeps the engine practically new in all essential points, and because duplicate parts are cheaper than ordinary repair work.

Q. If a wheel does not go easily on the

end of an engine shaft, what is to be done?

A. Look carefully for bruises and burs, and never try to force the wheel. It should slide on easily.

Q. If a new engine, in the course of a few weeks, has one of its wheels begin to travel along the shaft, what is the cause?

A. Only one set screw has been tightened when the wheel was originally put on.

Q. What effect has this on the bore of the wheel?

A. It will usually be battered out to an oval tapering hole, and cannot be repaired except by boring out larger and bushed down to the size of shaft.

Q. If the shaft appears to spring, where would you look for the cause?

A. If the spring appears to be the same on light and heavy loads, the centre bearing is probably too high. If it springs on heavy loads but not on light, it is probably too low. If adjustment of the centre bearing does not remove the spring, the shaft has probably been bent in shipment, or by battering on a wheel with a bruised fit.

Q. What are the principal requirements for making a Westinghouse engine operate satisfactorily?

A. Intelligent oversight rather than frequent adjustment. Good oil, and careful starting and stopping.

Q. Why can the parts between the shaft and the valve on this type of engine be left more slack than on others, even though they are double acting?

A. Because they are so much better lubricated, that there is quite a large cushion of oil between the surfaces. This is most noticeable on the eccentric strap, which should never be set down too hard on the eccentric.

Q. Why should a cylinder lubricator be set to work very slowly on a Westinghouse engine?

A. Because the pistons get an excellent lubrication from the crank case, and the oil from the cylinder lubricator is only needed to give a little lubrication to the valve.

THE WHEELOCK ENGINE.

Q. How do you increase the speed of a Wheelock engine?

A. By counteracting the centrifugal force of the governor by hauling the spring on the trip rod. (This can be done while the engine is in motion.)

Q. How do you make the cut off earlier at both ends?

A. By lengthening the trip rod from the governor.

Q. How do you make the cut off earlier at either end?

A. By changing the trip rod between the two cut-offs; there being a right and a left handed screw which can be operated while the engine is in motion.

Q. How do you adjust the exhaust release?

A. By allowing the driving links to pass by their centres more or less as is desired; the further they go the later the release.

Q. Can you change the exhaust release at one end without affecting that at the other?

A. Yes.

THE WHITING ENGINE.

Q. Give full description of how you would proceed to set up a Whiting automatic engine, if every piece were separate from the others?

A. Place crosshead in frame, take rod pin from crosshead, place rod in position in crosshead, replacing pin and setting up nut on pin tight; then adjust rod brasses by wedge bolt, being careful to set up nut on bottom of wedge bolt tight.

Take shaft, wipe carefully and place in bearings, and put on crank, brasses, and rod straps. Put on automatic device with steam eccentric into fly-wheel (cut of automatic device is given below), fastening all nuts carefully, so that none of the joints will bind. Slip fly-wheel on to shaft, being careful to screw set-screw into cup in shaft made to receive it, then slip in place, key, driving up key to close fit.

Wipe out cylinder and steam chest carefully, oil well with hand both the cylinder and steam chest; slip valves in place, being careful to have the sleeves on both ends of

chest loose in the head plates, so that the valves will work perfectly free through the steam chest. Carefully tighten steam chest heads, then carefully tighten valve stem sleeves, being careful that no dirt gets under the sleeves, which would bring undue pressure both on the valve and valve stems.

Slip piston in place, springing rings into the cylinder, and screw into the crosshead, being careful to give equal clearance on both ends of cylinder. Place rocker arms in their boxes, slip exhaust eccentric on to shaft opposite fly wheel, being careful to set set-screw in eccentric into hole in shaft made to receive it. Couple eccentric straps with blades to eccentric and rocker-arms; couple valve stems to rocker-arms, being careful to screw valve stem up to marked point indicated upon the stems, and set lock-nut up tight. This will insure the proper distribution of steam into the cylinder.

All parts should be carefully lubricated, and sight-feed and oil-cups carefully adjusted. Before starting, allow cylinder to drain thoroughly from water, and to be somewhat heated by steam.

Q. How would you take up lost motion in the crosshead?

A. Loosen jam-nuts on set-screws near top and bottom of crosshead on piston side, and turn set-screws slightly—say one-quarter of a turn. This forces wedge into crosshead, which pushes out shoes on top and bottom. Set jam-nuts tightly before starting.

Q. How would you take up lost motion in the main rod?

A. Loosen the hex nut on bottom of rod (not the strap bolts), and give top hex cap-screw the necessary turn, or fraction of a turn, to tighten boxes; then tightly set up hex-nut on the bottom of rod. This raises the wedge which lies between the strap and brass, and holds the boxes closer to the shaft.

Q. How do you increase speed of Whiting automatic engine?

A. By shifting the weights on the weight levers on the automatic governor toward the fulcrum of the lever, maintaining an equal distance from each fulcrum to centre of each weight. If this does not increase

the speed enough then tighten up the governor springs. It is preferable, however, to have the weights changed to a lighter pair where great change of speed is necessary.

Q. How would you make the engine run slower?

A. Shift weights to extreme end of weight levers; or better, put on heavier weights.

Q. What effect would increased spring tension have upon speed?

A. A slight change in the tension of springs should not have any bad effect upon the governing of the engine; but undue tension destroys the equilibrium between the weights and tension of spring, and tends to make he engine "race."

Q. Can you change the point of cut off f a Whiting automatic ngine?

A. As the point o cut off is determined by the speed of engine through the automatic device it cannot be controlled at will. The point of cut off continually changes with the amount of work to be done.

Q. Can you make the exhaust release earlier?

A. Yes; by advancing the exhaust eccentric upon the shaft. The engines are cushioned according to the speed and the work to be done.

THE WOODBURY BOOTH.

Q. How would you set the valves of a Woodbury Booth automatic cut-off engine, one to cut off at three-quarters of the stroke, the other at one-half?

A. If it is the old fixed cut-off engine, in which there is a main valve for steam distribution and exhaust, and a flat cut-off valve working on a partition in the chest, the former is a plain double "D" slide valve, and the same instructions can be given as for any other similar valve. The eccentric hub is held to shaft with a counter sunk screw, which gives it its proper position, and all that is necessary is to adjust the length of the rod so that the valve is just starting to open, or "line and line" on each dead centre. They usually set the main valve to cut off at about three-fourths stroke. The cut off or outside valve, is

also driven by an eccentric, and its position is adjusted for different points of cut off by moving the eccentric around on the shaft. If you adjust the length of rod so that cut-off shall be equal at each end, the opening of cut-off valve will take place earlier on one end than on the other; but this does not matter, as it will not open at either end until after main valve closes. You can adjust rod length so as to give unequal cut off.

THE REEVES VERTICAL COMPOUND ENGINE.

Q. What are the essential features of the Reeves compound engine?

A. It consists of two cylinders, side by side, connected to cranks at 180 degrees, so that the high-pressure steam acting upon one crank is transferred at exhaust directly through the valve of the low pressure cylinder to its piston without a receiver or connecting pipe.

Q. What other points in its construction are worthy of note?

A. The cylinders being placed close together on the same bed-piece, makes possible the largest power in the smallest

space with the essential economy of avoiding loss of temperature in receivers and connecting pipes, thus enabling the use of high-pressures and high speeds with the most direct transfer of the exhaust of the high-pressure cylinders to the piston of the low-pressure cylinders at the moment of the end of its stroke, and by this means equalizing the power of each cylinder in the most economical manner.

Q. What are the proportions of the cylinders?

A. Their diameters are generally two to one or the low-pressure cylinder has four times the area and volume of the high-pressure cylinder, thus making four expansions from the exhaust of the high-pressure cylinder.

Q. How many expansions does the steam make in the high-pressure cylinder?

A. The expansion in the high-pressure cylinder may be variable and governed by the cut-off to meet the power required with the least volume of steam at any given boiler pressure.

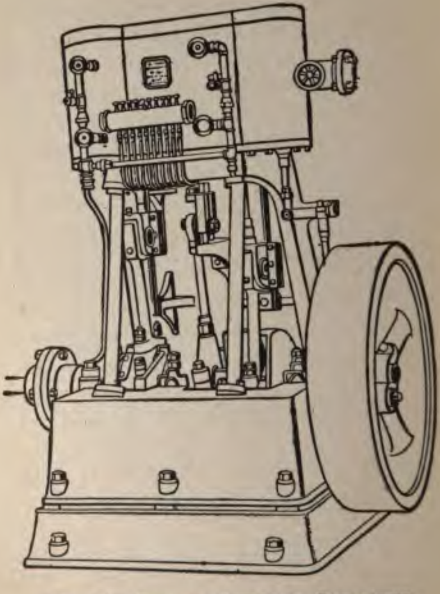

FIG. 148. REEVES VERTICAL COMPOUND ENGINE.

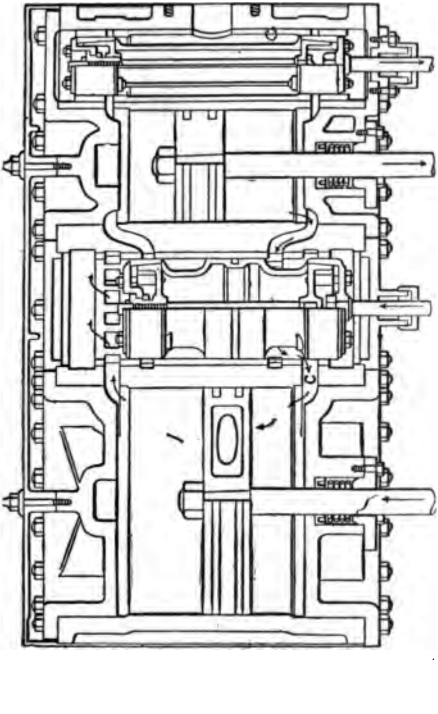

FIG. 149. CYLINDERS AND VALVES—REEVES COMPOUND VERTICAL ENGINE.

Q. How are the valves arranged?

A. Both valves are of the piston type as shown in Fig. 149, with a unique expansion adjustment for wear which can be made without removing the valve from its chamber. The low-pressure valve is directly connected by eccentric to the shaft and set for three-tenths cut-off, which gives compression in the high-pressure cylinder. The smaller valve of the high-pressure cylinder is operated by a cam on the main shaft and regulated by an inertia governor on the inside of the fly wheel in the vertical engines, and from a pin in the governor arm in the horizontal engines.

THE PAYNE TANDEM COMPOUND ENGINE.

Q. What are essential features of a tandem engine?

A. The general arrangement of a tandem engine is to place the cylinders one ahead of the other, both cylinders operating a single crank, so that in tandem compound the low-pressure cylinder may be forward or behind the high-pressure cylinder with their respective pistons on

a single piston rod, as shown in the Payne type, Fig. 150.

Q. How are the cylinders of the Payne tandem engine as shown in the cut opened for examination?

A. The back head of the low-pressure cylinder can be taken off as usual. The front head is made in two sections which can be unbolted and taken off the continuous piston rod when by unbolting the back head of the high-pressure cylinder and unclamping the crosshead, both pistons, rod and head can be passed out through the low-pressure cylinder.

Q. How are the valves operated?

A. As both pistons move in the same direction at the same time, the valves of the high and low pressure cylinders also move together in the same direction on a through valve rod connected by arms on a rocker shaft to a pin on the arm of an inertia fly-wheel governor as shown in Fig. 150.

Q. What is the action of the inertia governor?

A. Looking at the fly wheel, Fig. 150, it will be noticed that the center line of

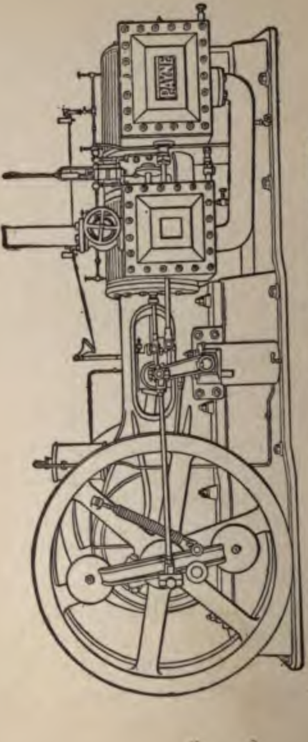

FIG. 150. PAYNE TANDEM COMPOUND ENGINE.

the straight arm and weights lies across the center of the shaft and balanced at their axis of revolution. They are pivoted to an arm of the fly wheel at a distance from their center and at one side of their center line. The spring,

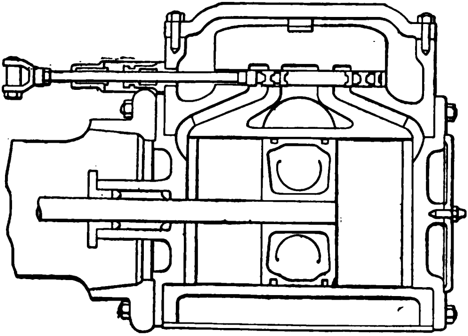

FIG. 151. PAYNE BALANCED VALVE.

by its tension and position of its attachment to the arm, draws the arm against a stop on the opposite side of the hub. When in motion the centrifugal force of the weights *throws* them forward against

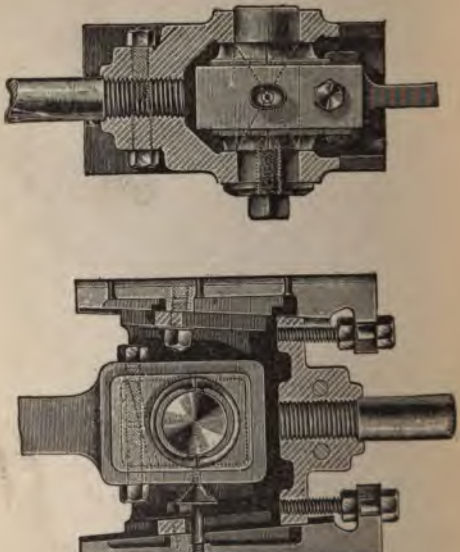

FIG. 152. PAYNE CROSSHEAD.

the tension of the spring and shortening the throw of the valve and its cut-off to suit the requirement of speed as adjusted by the tension of the spring.

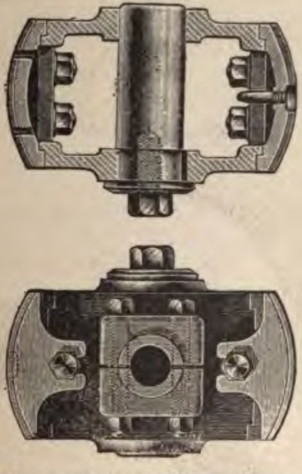

FIG. 153. SECTION AND END OF CROSSHEAD

Q. What does the inertia action mean?

A. The revolving motion of the weights when the engine is running steadily at

its normal speed, is the same as the speed of the fly wheel; but it is well known that the engine does not run at absolutely uniform speed and that the piston impulse is not the same during a single stroke. The acceleration and retardation of the motion of the fly wheel displaces the relative position of the weights and thus lengthens the throw of the valves during retardation and shortens the throw during acceleration of the fly wheel.

Q. Is there any peculiarity in the construction of the Payne valve?

A. Yes. It is a balanced, double ported slide valve as shown in Fig. 151. It is perfectly balanced and may be moved by hand under steam pressure. The valve is a flat ported plate with perfectly parallel faces. The balance cover is also ported to correspond with the cylinder ports and is supported just free from the valve by side bearings which are adjustable for valve wear. The cover is held in place by a spring on top which allows the valve to raise off its seat to allow entrained water to escape.

Q. How is the horse power of a simple engine obtained?

A. By multiplying the mean engine pressure by the area of the cylinder in square inches and the speed of the piston in feet per minute together and dividing the product by 33,000.

Q. How is the mean engine pressure obtained?

A. From the table of cut-off and mean pressure due to the initial or boiler pressure at one pound. For other initial pressures multiply by the decimal proportion for the mean pressure. If the cut-off is unknown it may be found in engines that can be readily turned over, by opening the drip cocks and slightly starting the throttle valve from its seat, so as to admit no more steam than the drip cocks will blow off, when by turning the wheel over until the steam ceases to blow and measuring the advance of the slide and comparing with the length of stroke, a fair measure of the cut-off may be obtained.

Q. How much power may be gained by compounding without condensing?

A. While the best performance of a good single cylinder engine at 80 pounds initial pressure is with ¼ cut-off about 24 pounds of water evaporated per hour per horse power; the compounding of the

TABLE.—MEAN AND TERMINAL PRESSURE IN PERCENTAGE OF INITIAL PRESSURE WITH 7 PER CENT. CLEARANCE.

Cut-off.	Cut-off. Per Cent.	Mean Pressure. Per Cent.	Terminal Pressure. Per Cent.
$\frac{1}{10}$	.10	.413	.159
	.15	.495	.210
$\frac{1}{5}$	.20	.567	.25
$\frac{1}{4}$	.25	.637	.298
$\frac{3}{10}$	.30	.692	.345
$\frac{1}{3}$	.333	.720	.380
$\frac{3}{8}$	.375	.766	.417
$\frac{4}{10}$	.40	.787	.439
$\frac{1}{2}$	.50	.86	.532

same engine cylinder with a small advance in the cut-off will make a possible 21 pounds per horse power and will nearly double the power of the high-pressure cylinder.

Q. How much power is gained by condensing in single cylinder engines?

A. About 12 pounds per square inch of cylinder area multiplied by the speed of the piston in feet per minute and product divided by 33,000 equals the horse power gained. The vacuum pressure is approximately an assignable ratio to the mean steam pressure in the cylinder for the percentage of power gained.

Q. How much power may be gained by compounding and condensing?

A. The principle of condensing largely increased the economy of steam power; bringing the volume of water in steam to about 14 pounds per horse power hour, and coal to about 1¾ pounds per horse power hour in two-cylinder engines, and to 12½ to 13 pounds of water in steam and from 1¼ to 1½ pounds of coal per horse power hour with pressures up to 150 pounds per square inch.

Q. How is the horse power of a compound condensing engine obtained?

A. The practice in designing compound and compound condensing engines is to make *each cylinder* of equal power for

the assigned initial steam pressure, so that the horse power of the high-pressure cylinder multiplied by the number of cylinders is an approximation to the horse power of the engine.

Q. How can the horse power of the high-pressure cylinder be obtained?

A. First, by knowing the cut-off and initial pressure from which the terminal pressure (back pressure) may be found in the table of theoretical pressures here given for various points of cut-off. Second, as the terminal or back pressure is nearly an average constant throughout the stroke of the piston, it should be subtracted from the mean pressure due to the initial pressure and cut-off. Thus for 100 pounds initial pressure and 4-10 cut-off, the mean pressure in the third column of the table is 78.7 pounds and the terminal in fourth column is 43.9 pounds, leaving 34.8 pounds as the actual mean pressure of the high-pressure cylinder. From this figure find the horse power of the high-pressure cylinder as before described and multiply it by the number cylinders for the total horse power of the engine.

Q. How much saving in fuel may be had by heating the feed water?

A. As much as 13 per cent of the fuel may be saved by heating the water from 60 degrees to 210 degrees Fahr. by the exhaust or the waste heat from the flues. In winter time, when water is at a temperature of 45 degrees or less, more than 14 per cent may be saved in the coal pile.

The following table makes a comparison of saving at various temperatures.

TABLE OF PERCENTAGE IN SAVING FUEL BY HEATING THE FEED WATER. STEAM AT 70 POUNDS AND APPROXIMATE FOR OTHER PRESSURES.

Initial temp'r-ature.	130°	150°	170°	190°	200°	210°
50°	6.89	8 64	10.38	12.11	12.98	13.85
60°	6.08	7.84	9.60	11.34	12.22	13.10
70°	5.26	7 03	8.80	10.57	11.45	12.34
80°	4.42	6 21	8.00	9.78	10.67	11.57
90°	3.58	5 38	7.18	8.98	9.88	10.78
100°	2.71	4.53	6.35	8.16	9.07	9.98

Q. What is superheated steam?

A. Steam is said to be superheated when its temperature is higher than the water from which it was generated. It cannot be superheated when it is in contact with the water in the boiler.

Q. How is superheating done?

A. By heating above its normal temperature in pipes or chambers by the waste heat of the flue for near-by use or by a separate fire at a distant point.

Q. What economy has been found in superheating steam for engine use?

A. Superheating converts the water of condensation in steam pipes into steam, and partially prevents condensation in the cylinder by expansion and in a general way increases the volume of steam. Superheating is limited to a temperature that will not destroy packing and lubricants or to about 400 degrees Fahr. Its best effect is with low and medium steam pressures.

Q. What is a turbine steam engine?

A. A rotary engine in which power is produced by the impact of steam on blades inclined or otherwise, by a simple effect as in the De Laval type or repeated

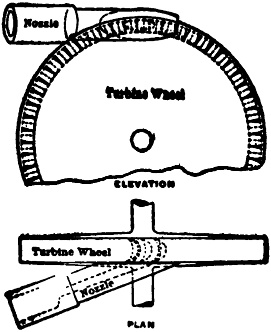

FIG. 154. DE LAVAL.

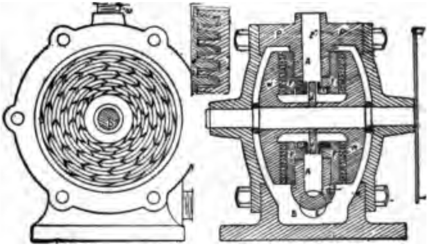

FIG. 155. DOW.

on a series of inclined blades placed radially on disks with intervening counter inclined blades on stationary disks, as in the Dow and Parsons steam turbine.

Q. Are steam turbines economical as a type of motors?

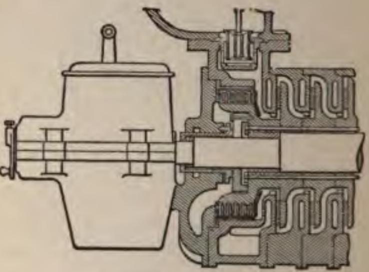

FIG. 156. PARSONS.

A. Not more so than ordinary types of reciprocating engines. Their principal advantage is in high speed enabling their direct connection with high speed electric generators. For special purposes it is claimed that a speed of 10,000 revolutions per minute has been attained, and that

a lightness of less than 7 pounds per horse power has been realized.

Q. Is the principle of expansion utilized in steam turbines?

A. Yes; to atmospheric pressure and to a vacuum in the Parsons type.

Q. Are rotary engines considered an economical type?

A. No. Of the many hundred that have been patented, but few are in use, or have been made a commercial success. They are wasteful of steam and frail in wearing qualities.

Q. How do you find the cause of knocking or pounding in engines?

A. First trace up the place by the ear placed near the suspected location and then examine everything there that is liable to get loose and produce noise.

Q. What are some of the causes of knocking?

A. The most common causes are lost motion at the crank pin or crosshead pin by wear; sometimes at the crankshaft journals, and often in vertical engines the journal box caps get loose from the alternating vertical thrust. A side

thrust at the crank-pin box from a loose fit that would scarcely be noticed on inspection will cause a knock by the sudden impact of steam on the piston when there is no cushion. A most mysterious cause, difficult to inspect, is a loose fit in the piston rings; when their large surface, however small the motion, may produce a slap at every change of motion in the piston. Looseness of piston-ring springs and loose binding nuts to the springs—all hidden sources of noise not easily recognized except by expert ears. Other noises are frequently traced to looseness in the valve-rod fastenings to the valve or looseness of the strap in the class of engines with valve strap.

The valve-rod joint with the eccentric rod and with complex valve gear is often a source of noise—all of which should be easily found by an expert ear. Their remedy in all these cases is suggestive when the actual conditions become known, and in most modern engines adjustments are provided for every supposable defect from wear.

A strange and sometimes difficult cause

to find of knocking has been found in the looseness of the fly-wheel keys, because of the danger of close examination when the engine is running; and still another in the looseness of a sectional arm of a fly wheel.

Q. What special means can be used to detect the location of knocking?

A. If the hand or fingers fail to find the location and it seems to be hidden, a strip of wood like a pencil may be placed against a stationary surface as near as possible to the supposed locality with the other end between the teeth when by closing the ears with the fingers an increased sense of vibration may be felt as the wood touches near the trouble.

THE END.

INDEX.

An asterisk (*) indicates an illustration. Things should be looked for under the principal word, although in some instances opinions may differ as to which one to look under. Most phrases are indexed under more than one word.